A Summary of Current Program, 7/1/63

and Preliminary Report of Progress

for 7/1/62 to 6/30/63

ANIMAL HUSBANDRY RESEARCH DIVISION

of the

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued between July 1, 1962, and June 30, 1963. Current agricultural research findings are also published in the monthly U.S.D.A. publication, Agricultural Research. This progress report was compiled in the Animal Husbandry Research Division, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Md.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C.
July 1, 1963

TABLE OF CONTENTS

INTRODUCTION

The mission of the Animal Husbandry Research Division is to conduct research which will reduce costs of animal production, provide the consumer with animal products of improved quality, and provide basic animal science information. Livestock and poultry producers are faced with the mounting pressure of ever growing marketing costs, and reduced production costs are essential to continued profits. In their efforts to solve practical problems of animal production, scientists are constantly confronted with a paucity of basic information on the genetics, nutrition and physiology of livestock.

The investigations of the Animal Husbandry Research Division are carried out by a staff of 524 persons, of whom 166 are professional research scientists. The work is conducted at Beltsville and at field locations throughout the United States. Many of the projects are carried out cooperatively with State agricultural experiment stations. Investigations are carried on in genetics and breeding, nutrition and feeding, feed composition and evaluation, anatomy, physiology, and management. National cooperative records of performance programs are conducted with dairy cattle and poultry. Research also is conducted on the quality of meat, milk, and eggs, as influenced by production factors; on the basic metabolism in the animal body of pesticides, hormones, and other chemicals used in agricultural production and the effects of these chemicals on animal products; and on the control of avian leukosis in poultry.

Most animal husbandry investigations are necessarily long term in nature. Thus, it is easy to lose sight of the degree to which progress has been made in a yearly published report such as this. Mentioned briefly below are a few of the more recent developments which have made marked contributions to the industry and/or to their fields of research.

Acid-detergent-fiber content of forages. For nearly 100 years the crude fiber content of forages has been used as an approximate method of evaluating value of forages. Research on the chemical fractionation of forages, especially the carbohydrate components, and the relation of forage composition to digestibility of these forages, has shown that an acid-detergent-fiber fraction of forages is highly correlated with forage digestibility. The correlations are much more precise than those obtained with crude fiber. This procedure is now being used widely as a research tool in forage evaluation studies and, to a limited extent, in commercial forage testing programs.

New DHIA sire evaluation. A new method is being used by the USDA for DHIA sire evaluations. The dam-daughter comparison proved-sire record has been replaced by sire summaries using daughter-herdmate comparisons. The new method eliminates much of the bias and error inherent with the older technique and provides dairymen with a greatly improved sire record, particularly for sires used in artificial insemination. New data processing methods will permit computation and issuance of quarterly instead of once a year sire summaries. In addition, cows with superior breeding values will

be identified for use in making matings to produce future bulls.

Fatty acid deficiency in the laying hen. After two years' effort the first true fatty acid deficiency, with easily recognized symptoms, was produced in laying hens after a long depletion period. The symptoms are extreme susceptibility to respiratory infection and an alteration in fat metabolism to produce a rare and as yet undesignated fatty acid. A progressive degree of deficiency resulted in small egg size, prolongation of hatching time, severe decrease in egg production, and eventually zero hatchability. It has been shown that, of the several fatty acids formerly thought to be essential, only linoleic acid is essential in the laying hen.

Higher reproductive rates from crossbreeding of sheep. Crosses of Hampshire, Shropshire, and Merino sheep at Beltsville have shown that reproductive efficiency was higher for crossbred than for purebred matings. Furthermore, there was an upward trend with an increase in the number of breeds involved in the cross. Average increases in percent lambs weaned of ewes bred were 2.1, 14.9, and 27.1 for 2-, 3-, and 4-breed crosses, respectively, over the comparable averages of the purebred parents.

Ram behavior studies aid in sheep improvement. Studies at Dubois, Idaho, have shown that when more than one ram is used in breeding a group of ewes an order of dominance is quickly established. Mature rams were always dominant over yearling rams. In rapidly improving flocks yearling rams are often genetically superior to older rams. Thus, the use of dominant rams of inferior genotype could greatly affect the average merit of the lamb crop. Also, dominant rams which happen to be sterile or of low fertility could greatly reduce the lamb crop and extend the lambing season.

"Break-through" on iron-deficiency anemia confirmed. In trace mineral studies at Beltsville on young pigs, three oral preparations containing iron were tested for effectiveness of claimed protection of baby pigs from iron-deficiency anemia by increasing the iron content of sow's milk. Two of these preparations were found to be ineffective. The third compound gave satisfactory protection to baby pigs which suckled iron supplemented dams. These results confirmed similar findings at the Kentucky, Louisiana, and Iowa Experiment Stations. This represents an important "break-through" in situations where iron therapy has had to be given directly to baby pigs.

Microbes help with pesticide residue problems. Ruminal protozoa, cultured as individual species, offer definite promise as a screening technique for determining if pesticides will leave residues in meat and milk of cattle and sheep. Ruminant animals possess large numbers of microorganisms in their digestive system, particularly the rumen which appears to be the natural site for the microbial degradation of complex compounds such as pesticides. Pesticides, if degraded in this manner, will not produce residues in the meat even though they are consumed with the feed. Ruminal protozoa were found to metabolize the following pesticides: Diazinon, dimethoate, lindane, Thiodan, and Sevin.

AREA NO. 1: ANIMAL BIOLOGY

Problem. The extent of applicable results in animal husbandry research is severely limited by a paucity of basic information on the genetics, nutrition and physiology of our livestock. The basic research in progress has resulted primarily in revealing the inadequacy of our information regarding the functional processes within the animals we are trying to control and develop for human use. Basic research is required in such fields as animal cell metabolism and reproduction, enzymology, physiological bases for heredity and microbiology of the rumen and intestines. Results of such studies provide the basis for additional research applied to the husbandry of each type of livestock.

USDA PROGRAM

This area consists of basic research conducted by geneticists, biochemists, physiologists, and nutritionists. It includes studies in the Pioneering Laboratories on somatic variations of red cell antigens, on the nature of the specificity of antigens and antibodies, and on methods and theories of population genetics. Research in reproductive physiology is in progress to determine the biochemical composition and the defensive mechanisms of the uterus. Still other physiological investigations are involved with the response of mammary tissue to invasion by infectious agents. One study of long standing has the primary objective of describing, fully and in detail, the gross and microscopic anatomy of the domesticated fowl. Research on the metabolic role of vitamin B_{12}, the investigation of unidentified nutrients in food and feed, and biological and chemical studies of rumen metabolism are also being undertaken. Investigations are in progress on the development of counter measures to prevent contamination of animal products by fallout from nuclear explosions. The work is conducted at Beltsville, Maryland, East Lansing, Michigan, and in cooperation with the Indiana, Iowa, Maryland, Michigan, Minnesota, Utah and Wisconsin Agricultural Experiment Stations.

The Federal scientific effort devoted to research in this area totals 21.0 professional man-years. Of these, 5.5 professional man-years are in genetics, 8.7 in physiology, 2.0 in nutrition, 3.5 in rumen function, 1.0 in radio active fallout, and .3 in program leadership.

There are six grants involving Public Law 480 funds in foreign countries financing research related to animal biology. One is with the Polish Academy of Sciences, Jablonna, Poland. The project is on the secretion of anterior pituitary hormones and ovulation in small ruminants. It is supported for five years (1960-1964) by $34,954 equivalent in Polish zlotys. A second project was initiated in Poland with the College of Agriculture at Poznan on protein compounds of vitamin B_{12} and its analogs. It has a duration of four years (1962-1965) and involves $38,138 equivalent in Polish zlotys.

Two projects were initiated with Israel during the year. One is on factors affecting long-term storage of sperm in vivo and the other is on the separation of young and old spermatozoa. Both are with the National and University Institute of Agriculture, Rehovot. They are supported for 3 years (1963-1965) with a total of $86,803 equivalent in Israeli pounds.

A study has been in progress with The Institut Espanol de Fisiologia y Bioguimica, Madrid, Spain, since 1961. The project is entitled "Study of Metabolism of Zinc in Living Organisms by Means of Zinc 65." It has a duration of four years (1961-1964) and is supported by $35,277 equivalent in Spanish pesetas.

A project was initiated with the University of Montevideo, Uruguay, on the nutritional value of fish silage. It is supported for 5 years with $112,785 equivalent in Uruguayan pesos.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Genetics

1. Methods and theories of population genetics. Experimental evaluations of the methods and theories of population genetics are underway at Lafayette, Indiana, in cooperation with the Population Genetics Institute of Purdue University. (AH P-2)

(a) Research on mice. The data and the mice from two classical selection experiments of Dr. H. D. Goodale at Mount Hope Farm were made available to this laboratory through the generosity of the Prentice family. These unique materials provide an unmatched opportunity to investigate the nature, problems and limitations of genetic changes in populations over many generations. Both experiments were initiated by Dr. Goodale in 1931 and have been continued here since 1959.

The Goodale Large White population was started from 5 males and 11 females and has been selected for 60-day body weight. Individual data from 54,653 mice of the first 85 pedigreed generations were transferred to punched cards, adjusted to a male sex basis, transferred to magnetic tape and processed on a high speed computer. Although further analyses remain to be completed, the results for each generation are available. Mean body weight increased consistently during the first 35 generations of selection. A long period of plateau apparently followed because 47 additional generations of selection produced little or no increase in the mean. The mean weight increase in the last three generations was associated with major changes in management and environment and may be largely environmental.

The absence of selection progress during the plateau period could be explained very nicely by the absence of additive genetic variance. However, such is not the case. Analysis of each 10-generation period and the final 15-generation period by the variance component method reveals

a reduction in the proportion of additive genetic variance but definitely not an absence. The average heritability estimate based on the sire component was 47% lower in the last 55 generations than in the first 30 generations, but remained at an appreciable level. Only the estimate for the sixth period was below 15%. The average heritability estimate was reduced 37% from the first four to the last four periods. It is clear that either the sire component is consistently biased upward during the plateau or the plateau is caused by some factor(s) other than exhaustion of additive genetic variance.

All heritability estimates based on the dam component were above unity except the estimate for the first period. This would lead one to postulate a very large maternal effect. Again, the obvious interpretation is probably incorrect. Regressions of offspring on dam, calculated over all sires in each generation, average somewhat larger than regressions of offspring on sire in the first 35 generations but are slightly smaller thereafter. It is suggested that the estimate based on the dam component is seriously biased by environmental factors associated with but not caused by the different dams mated to a sire.

In the analyses by periods, the pooled within-litter variance increased steadily in each period except the sixth. Such an increase is expected during the period of increasing weight, but is unexpected during a plateau. Pooled total variance within generations also increased greatly during the experiment but the changes were less consistent.

The sex ratio (as measured by percentage of males) showed a slow but steady increase from a low value to a high value during the whole experiment. The biological reason for the sex ratio change is not clear but it may be related to changes in litter size.

Average sizes of litters born and weaned per generation revealed an interesting pattern. Litter size was quite low in the first generations and, in general, tended to increase during the period of weight increase. Further increases, possibly due to better management, appeared to occur after the plateau for weight had been reached. Litter size continued to fluctuate around a rather high level until some decrease occurred in the later generations. It is clear that this population did not plateau because of poor litter size. However, a high rate of sterility in this population has been observed. Although sterility records have not yet been analyzed, the possibility remains that the plateau may be due in part to a high rate of sterility in the heavier individuals.

The second long-term experiment involves selection for amount of white hair. It was started by Dr. Goodale in a stock derived from one male mouse with a few white hairs on the forehead and four self-colored females. A sample (5 males and 6 females) of the selected stock was transferred to this laboratory and results are available on eight generations (913 mice) produced from the sample. The balance of the

population was moved here last fall.

All mice were scored at weaning for percentage of white on the dorsal surface. The unweighted mean percent white over eight generations is 69.5 for males and 64.9 for females. Regression of sex means on generations shows an average increase per generation of 1.85% white for males and .70% for females. Realized heretability is .15 ± .06. Heritability estimated from regression of offspring on midparent is .17.

Lyon's recent proof of random sex chromosome inactivation in female mice requires theoretical changes in components of parent-offspring regressions when sex-linked effects are present. Regressions of female offspring on each parent contain only half of the sex-linked effect. When both maternal and sex-linked effects are present, the expected values of the four types of regressions (each sex of offspring on each sex of parent) are different. The four types of regressions were calculated. These limited data showed only that regression of male offspring on dam was largest, as expected, if maternal and sex-linked effects are present.

Standard deviations of percent white hair were very large (15 to 23 within sex and generation). Coefficients of variation tended to be larger in females but showed no consistent trend with generations. Realized selection differentials were slightly larger than expected selection differentials, indicating no tendency for higher scoring fertile individuals to produce fewer offspring.

Beginning in the fifth generation, two or more all-white dark-eyed males were obtained in each generation for a total of eleven. One all-white female was obtained in the eighth generation from an all-white sire. Tests show the absence of albino and the absence of genes dominant to wild type in all-white males.

Although the number of generations of selection is not yet known, it must certainly exceed 70. It is obvious that genetic change is still occurring in this population long after a plateau has been reached in the weight-selected population. The tremendous changes already obtained in the mean and variance indicate the presence of a very large amount of cryptic variation in the foundation animals or some unknown source of new genetic variation. The mean of this sample does not approach the absolute selection limit but a dozen individuals have reached the phenotypic limit.

(b) Research on Tribolium (a flour beetle). The experiment previously reported concerning effects of mating systems and selection methods on a heterotic trait has been repeated on an additive trait. The same design and population were used for investigating the highly heritable trait, pupa weight, through six treated generations. All combinations of mass or individual selection (M) and random or no selection (R) with mating systems assortative (a), disassortative (d), random (r),

outbreeding (O) and inbreeding (i) were tested in two replications. Analyses of the data are partially completed.

Heritability of pupa weight was .46 ± .09 when calculated from regressions of offspring on midparent of both replications in the untreated generation. The average realized heritability for the experiment was .33 in the M groups of both replications. The descending rank of mean pupa weight averaged over both replications of generation six was Ma and Mo (nearly identical), Mr, and Mi and Md (nearly identical). The differences are not significant. Mating systems appear to have had little or no effect on selection for this trait through six generations. Mating systems had no significant effect on random selection although Rd tended to be lower than the other systems. As expected, the differences between M and R groups were highly significant because selection gave consistent progress. Analysis of the regressions of mean weight on generations show that the effect of mating systems in the M groups is significant only at the 25% probability level.

Average inbreeding coefficients over both replications in generation six were lowest for Ro (.04) and highest for Mi (.36). They were generally higher in the M than in the R groups.

The increase in genetic variance (and consequently in phenotypic variance) expected under assortative mating apparently failed to materialize. Although some statistics remain to be calculated, present evidence indicates a disagreement between experimental results and theory. Further checks into the nature of the disagreement are planned.

2. Basic research on blood antigens and antibodies. (AH P-1)

(a) The nature of antigenic specificity. Studies of the "Hi" substances normally restricted to the red cells of sexually mature females were continued. The "Hi" substance is under the control of a single autosomal dominant gene and requires the presence of estrogen for its development. Progesterone and methyl testosterone have no stimulatory or inhibitory ability for the production of the "Hi" substance. Polyethylene glycol paste preparations of diethylstilbesterol given biweekly were found fully effective in stimulating "Hi" substance production; this procedure has completely replaced the need for daily subcutaneous injections of diethylstilbesterol, the method previously used for evoking the formation of the agglutinogen.

(b) Somatic variation of red cell antigens. Studies on somatic variation of red cell antigens in man and in pigeons are being continued. Young human red blood cell populations were obtained by hemolysis with hypotonic salt solutions. The A inagglutinable cell frequency was compared in the young cell population using an isotope dilution method, the isotope used was Cr^{51}. The inagglutinable frequencies were found to be not significantly different from each other: young - 1.96×10^{-2}; total

cell population - 1.61×10^{-2}. In another comparable experiment it was for the young cells - 5.66×10^{-3} and the total cell population 3.69×10^{-3}, indicating that the inagglutinable cells are neither young cells nor old cells.

(c) Model studies on antibody specificity. Studies on agglutinins specific for human A red cells have been conducted with extracts of Phaseolus lunatus (lima beans) and immune and naturally occurring human anti-A sera. Experiments have been carried out on the partial purification of P. lunatus extracts by conventional chromatographic procedures and alternately by absorption and elution from red cell stroma. These experiments became important for reasons other than purification when it was observed that antibodies could be differentially eluted from stroma at temperatures between 37°C. and 56°C. These thermal dissociation studies were continued using I^{131} labeled agglutinins enabling an estimate to be made of the purification achieved by thermal dissociation.

A modification of the triiodide method of I^{131} labeling of agglutinins was employed. The serological assay was based on agglutination titrations. The scores were transformed to log values, the sum of log values was found to be linearly related to the concentration of agglutinin. In the radioassay in saline media the labeled agglutinins tended to absorb to the glass wall of the tube with consequent high backgrounds; the use of 0.5% egg albumin and exhaustive dialysis of the labeled protein reduced the radioactivity absorbed to the glass surface from 50 - 75%.

The relationship between the log of absorbed radioactivity on to human A cells subtracted from that absorbed by human O cells was found to be linearly related to the $\log_2$ of the agglutinin concentration. This relationship was evident for a red cell volume of 0.25 cc but if quantities such as 0.08 cells were used, there was evidence for saturation of red cell sites with P. lunatus agglutinin. Similar experiments were also conducted with human anti-A serum with comparable results. As expected, a portion of the radioabsorption curve was found to be colinear with the agglutination curve. While the radioassay is restricted in its use to certain cell volumes and cell types, it will be extremely useful in many stages of purification and for many types of experiments. The serological assay and the radioassay appear useful and for most experiments provide data which tend to complement rather than duplicate.

The stability of the agglutinins was tested by exposing them to 56°C. or higher temperatures. The highest temperature to which the agglutinins were exposed during the elution experiments was 56°C. for 15 minutes and only prolonged incubations at this temperature resulted in substantial reduction of the agglutinin activity - for P. lunatus (40%), anti-A (35%), and anti-B (56.3%). An incubation period of five minutes at 76°C. was sufficient to completely inactivate the anti-A and anti-B agglutinins and moreover resulted in the complete coagulation of these sera. For P. lunatus a temperature of 90° C. for five minutes was required before complete inactivation took place. Ghost preparations were exposed to

temperatures between 24° C. and 70° C. for periods of 15 minutes. There were no differences among these ghost preparations in their ability to absorb anti-A activity as well as differences in the amount of eluate obtained from the ghost agglutinin complex. Absorptions with "O" cells resulted in as much as 300% increase in titer over the initial titer.

Previous results have been confirmed by more recent experiments in which it was possible to separate the anti-A agglutinins by thermal dissociation using I^{131} labeled anti-A sera. The ratio of serological activity to radioactivity suggested a considerable increase in purity; initially the ratio was 20:1, in the first stage of elution it was 46:1, and for the last elution at 56° C. it was 398:1.

B. Physiology

1. Avian anatomy. (AH e6-26)

(a) Topographic anatomy and externally palpable structures. Thirty-two original illustrations were completed, including three views each of the whole chicken, turkey, pigeon, and coturnix quail. Many of them give for the first time in any species of birds the name of the anatomical regions and landmarks of the bare body. The palpable structures can be accurately identified from other drawings of the underlying bones and muscles. Such information will greatly aid dissections and operations for physiologic studies.

(b) Arrangement of feathers. Fifty-two illustrations are now available on the arrangement of feathers. The drawings described in Phases 1 and 2 were used as the basis for transparent overlays showing the precise location of every feather. This was done in three views of each of the four species. Another series of overlays shows in an original fashion, the groups of feathers that arise on the major feather tracts of the chicken.

(c) Gross arrangement of feather muscles. Twelve new drawings and diagrams were prepared. Every feather in a tract is linked to adjacent feathers by tiny smooth muscles which affect their movement. This is the basis for the arrangement of feathers in rows. The intricate pattern of muscles is different on each tract, in relation to the movability and function of the feathers.

In some of the nonfeathered areas there exist broad sheets of isolated smooth muscle bundles located in the lower level of the dermis. Each minute smooth muscle bundle is joined at its ends by elastic fibers. We have not found these muscles described elsewhere in the literature.

(d) Details of feather muscles. Six illustrations of feather muscles are now available. Approximately eight muscle bundles are

attached to each follicle; between follicles they cross so that the top of one follicle is moved by a muscle that has its other end attached to the edge of an adjacent follicle. Thus, each feather is supplied with elevators and depressors. Even short bristle feathers have muscles attached to them. These small bundles of smooth muscle are supplied with more nerve terminals than are the large skeletal muscles of the body. The feather muscles are radially arranged around two levels of the follicle for those small feathers that are not part of a row. The surrounding connective tissue serves as anchorage for the muscle bundles.

(e) Sequence of feather succession and early molts. For these phases there are 10 charts in color, 18 drawings of feather generations and numerous photomacrographs to show emerging feathers. It was expected that there would be ample detailed information on the emergence of feathers and the molting process, but the literature is confined almost entirely to the flight tail and wing feathers.

(f) Distribution of arteries, veins, nerves, and lymphatics to the skin. The arteries and veins are covered by six large drawings in color. There are approximately 35 branches of arteries that supply the skin. These are paired with veins in most cases. The branch with the most extensive distribution is the A. thoracica lateralis. Each segmental twig emerging from a foramen of the pelvic girdle has an extremely limited distribution. The blood supply to the tarsus and toes is carried by several longitudinal vessels with numerous cross-connections.

The distribution of the cutaneous nerves has not yet been completed but the larger branches have been traced.

(g) The microscopic structure of feathers. Thirty-three drawings on this segment of work are now available. Feathers are complex structures that must be studied microscopically to be fully understood. There are six major types of feathers, and these vary among species as well as within different parts of the same bird. These variations in microscopic structure increase the difficulty of studying feathers, but on the other hand permit many feathers to be identified as to species and even body region.

(h) The histology of skin, dermal part of feathers, scales, claws, comb, wattles, oil gland, etc. This year 20 drawings have been made on these subjects, including one in color showing the base of a growing feather. The skin of birds is thin, there are no dermal papillae or sweat glands. Large capillary sinuses are present beneath the surface of the comb and wattles. The intermediate layer of the male has been reinvestigated and found to be mucofibrous rather than muco-elastic as given in the literature. The structure of the tubular leader of the turkey is different from that of the comb; in the former, true erectile tissue is present as well as longitudinal bands of smooth muscle. The epidermis on the beak has a layer of rectangular-shaped cells arranged in rows.

(i) Distribution, growth, molting of filoplumes. This work is covered by 12 photographs and a diagram. These studies have contributed more to the nature and development of these structures than all previous literature on the subject.

2. Composition of uterine tissue.

(a) Effect of histamine and estrogen on the glycogen content of the rat uterus. Glycogen is the principal storage form of carbohydrate energy in animal tissues, and levels of this compound in uterine tissue are markedly influenced by estrogen. Histamine has recently been proposed as being the mediator of estrogen action in the uterus, and studies were initiated to determine whether histamine could affect the glycogen content of the uterus in the same manner as estrogens.

After the administration of estrogen, uterine glycogen concentration was 3 times that of the control uterine horns. Intraluminal injections of free histamine, histamine dihydrochloride and saline control solutions elicited glycogen increases when a ligature was tied about the uterus during the injection. When no ligature was utilized, only free histamine administration resulted in a small glycogen increase.

This study demonstrated that intraluminal administration of histamine did not result in H_2O and glycogen responses similar to those produced by estrogen. Under the conditions of the experiment, free histamine caused a glycogen increase only about one-third of that elicited by estrogen, while histamine di-HCl elicited no glycogen response. The theory that estrogens act through the liberation of cellular histamine was not supported by the results of this study since exogenous histamine was unable to reproduce the glycogen response of estrogen. (AH h5-8)

(b) Role of histamine in uterine deciduomata. The decidual cell proliferation of the uterus which occurs during the artificial induction of deciduomata is very similar to the placental tissue which develops in pregnancy. In extensive investigations on the relation of deciduomata to implantation, it had been proposed that histamine was responsible for the induction of deciduomata. The major evidence, both direct and indirect, supporting this hypothesis was that locally introduced histamine in small quantity induced deciduomata, while antihistamines applied locally to the uterine epithelium blocked deciduomata development.

A series of experiments was initiated to further investigate the role of histamine in the induction of deciduomata. In preliminary studies, control solutions of water and saline were as effective as the histamine salt and led to further study of the handling and operative procedure and other control injections. The injection of air intraluminally was designed as a sham control, serving to demonstrate the effect of handling of the uterus and damage due to the needle puncture without involving the introduction of exogenous material into the uterus. The results indicated that air, distilled water and saline induced deciduomata to as great an extent as

histamine.

These experiments suggest that the injection procedure is probably the major factor in the induction of deciduomata when materials are administered intraluminally. Since no greater response was elicited by histamine than by the injection procedure, the effect of histamine cannot be separated from the effect of the concomitant operational procedure and injection vehicle. A specific role for histamine as a deciduomata inducing agent was therefore not supported by the results of these experiments. (AH h5-8)

3. Endocrine control of uterine defense mechanisms. A possible relationship exists between fertility and the uterine defensive mechanisms or their hormonal control. Investigations have been conducted on modes of endocrine control of the uterine defenses and possible species variation in factors related to the defenses.

Previous studies with rabbits have shown that estrogen stimulates and progestin inhibits the leukocytic response to inflammatory stimuli in the uterine lumen. These effects of ovarian hormones were related to control of endometrial vascular permeability. Endogenous progestin inhibited the increase in vascular permeability which was seen in estrous and ovariectomized rabbits; this suggested that maintenance by progestin of stable vascular permeability might be related to the maintenance of pregnancy. Studies have been continued in sheep and cattle on the hormonal control of the ability of the endometrium to respond to the presence of inflammatory stimuli.

(a) Control of the acute inflammatory response in the uterus of cattle. Estrous, luteal-phase and ovariectomized dairy heifers were inoculated in utero with Escherichia coli and killed 2, 3, 4, 8 and 16 hours later to study the tissue course of the inflammatory response. Leukocytic response at four hours was 300 times greater in the estrous heifers than in luteal phase heifers and the estrous uteri had 5 times more leukocytes than ovariectomized animals. Thus, the ovarian hormones of estrus stimulated leukocytic emigration while hormones of the luteal phase delayed leukocytic emigration. By 8 and 16 hours, however, this differential in response was no longer present and the leukocytic responses were similar in animals of each endocrine state. E. coli were cleared from the uterine lumens as leukocytic responses developed. Phagocytosis occurred extensively, and inflammatory exudates also contained noncellular bactericidal substances. The variation among endocrine states in volumes of sediment flushed from uterine lumens was much greater than the variation in most biological parameters measurable in cattle uteri. Thus, leukocytic responses to inflammatory stimuli may be a useful experimental tool in the study of endocrine effects on uterine function and on the responsiveness of endometrial tissues to endocrine stimulation.

(b) Control of the acute inflammatory response in sheep uterus. A previous comparison of induced inflammatory responses in uteri of estrous and luteal-phase ewes suggested that hormonal control of inflammatory responses in this species might differ from that in rabbits and cattle. The inflammatory response was slower in estrous ewes than in estrous rabbits or heifers. In a further study, estrous, luteal-phase and ovariectomized ewes were inoculated in the uterine lumen with Escherichia coli and killed 2, 4, 8, or 16 hours later. Large numbers of leukocytes had entered the uterine lumens at 4 hours in ovariectomized ewes, at 8 hours in estrous ewes and at 16 hours in luteal-phase ewes.

The leukocytic response was thus greatest in ovariectomized, intermediate in estrous, and slowest in luteal-phase ewes.

This hormonal inhibition of induced leukocytic emigration observed in estrous ewes was different from the effects of ovarian hormones of estrus in rabbits or cattle.

Vascular permeability in uterine endometrium and serosa was measured in ewes by the intensity of tissue bluing after intravenous injection of trypan blue dye. Permeability was highest in estrous ewes, intermediate in luteal-phase ewes and lowest in ovariectomized ewes. During induced uterine inflammation in ewes, endometrial vascular permeability increased greatly in ovariectomized ewes but little or none in luteal-phase or estrous ewes.

These results suggest that leukocytic emigration in inoculated sheep uteri was not entirely related to vascular permeability. Leukocytic responses were fastest in ovariectomized ewes, although permeability was generally highest in estrous ewes. The marked change in permeability in ovariectomized ewes may have been conducive to a rapid leukocytic response or some factor may have inhibited leukocytic emigration in estrous ewes despite the high permeability; endogenous progestin might have the latter effect.

4. Composition of mammary gland tissue. Studies were initiated on sheep mammary gland tissue to determine the normal composition in estrous and luteal sheep and in ovariectomized ewes. The changes occurring during experimental mastitis induced by bacteria were also determined.

(a) Chemical composition. Total mammary gland weight, water, fat, Na, Cl, K, DNA, RNA, histamine and glycogen concentrations were little affected by the endocrine status of the sheep. Significant differences in composition were found, however, between young and mature mammary gland tissue. The mammary glands from older animals were about 50% larger than those of young sheep. Water content was about 4% higher and the amount of fat was considerably greater in the young animals, being 27% as compared to about 12% of total mammary gland weight.

Previous results had indicated that the changes in mammary gland composition in response to the mastitis induced by Escherichia coli or Staphylococcus aureus are large at 4 hours after inoculation. Accordingly, the effect of inoculation of an udder half with saline alone was ascertained at this time interval. The saline inoculated mammary gland tissue was indistinguishable from the uninoculated tissue, no statistical differences being noted for any of the chemical constituents studied.

(b) Permeability in mammary gland during experimental mastitis. Non-lactating ewes in estrus, in the luteal phase and ovariectomized, were inoculated in 1 mammary gland with Staphylococcus aureus. Trypan blue dye was given intravenously and vascular permeability was measured by the intensity of tissue staining. Permeability had not increased at 1 hour, but had increased markedly by 2 hours. Tissue blueness at 2-3 hours was greater in estrous and luteal-phase ewes than in ovariectomized ones. Permeability at 5 hours was decreasing in estrous and luteal-phase ewes and was greatest in ovariectomized ewes. There was no indication that ovarian hormones, and particularly progestin, inhibited the vascular response to inflammatory stimuli; the mammary gland differed from the endometrium in this regard.

Leukocytic emigration was related to increases in vascular permeability, both in time of occurrence after inoculation and in variation among the 3 endocrine states in intensity of permeability and leukocytic responses.

Extravasation of circulating dye is considered to indicate the exudation of serum protein, since intravenously-injected dye is rapidly bound to serum albumin. Thus, plasma proteins probably entered inflamed mammary gland tissue at relatively rapid rates early in the inflammatory process. Studies are being made of the extravasation of circulating antibodies during induced acute mastitis. (AH h5-1)

5. Secretion of anterior pituitary hormones and ovulation in small ruminants. The mechanism of transmission of neural impulses from the hypothalamus to the pituitary, which regulate the secretion and release of pituitary gonadotropins, was investigated by two approaches. Neural transmission was studied by blocking the pathways with surgical severing of the pituitary stalk. Studies were also conducted on the effect of hypothalamus extracts on the release of pituitary gonadotropins.

A surgical technique for disconnecting the nervous pathways from the pituitary and hypothalamus was developed. The construction of an apparatus for fixation of the sheep's head facilitated the research. The technique was applied to 10 sheep with 8 survivals and to 15 rabbits with 10 survivals.

The neural pathway appeared to play a fundamental role in the function of the sexual organs and in the process of lactation. When the neural

pathway to the pituitary stalk was completely blocked, there was an absence of sexual cycles and atrophy of the uterus and ovaries in the ewe. Operations conducted in late pregnancy did not interfere with parturition but no milk secretion occurred. Stalk section on lactating ewes will also be studied.

When pituitary slices were incubated in vitro with extracts of the hypothalamus, there was an increase in the amount of gonadotropins released into the medium, as measured by uterine weight bioassay. These experiments will be extended by infusion of hypothalamic extracts directly into the pituitary and by electrophysiological stimulation of the hypothalamus. (E21-AH-1 - Warsaw, Poland)

C. Nutrition

1. Role of B_{12} in the metabolism of rumen fatty acids and related aids. The role of vitamin B_{12} in the metabolism of ruminants and other animals has not been fully elucidated. Previous studies at Beltsville have indicated that vitamin B_{12} is required for the metabolism of certain fatty acids which are produced in the rumen of cattle and provide a major source of energy for this species. This study has been extended to examine this relation of vitamin B_{12} to several other naturally occurring fatty acids and related compounds.

Results with formic acid, combined with those obtained earlier, support the previous indication that vitamin B_{12} is concerned in the metabolism of this acid. This finding with rats is consistent with in vitro results of other workers indicating (1) the involvement, in a bacterially derived enzyme system, of vitamin B_{12} in the metabolism of a recently disclosed form of folic acid (5-methylfolic acid), (2) the accumulation of this compound in the blood of patients with pernicious anemia, a disease caused by physiological deficiency of vitamin B_{12}, and (3) probable interference of such accumulation with the formation of tetrahydrofolic acid which is known to be concerned in formate metabolism. Thus the findings in these rat studies with formic acid are in accord with the pernicious anemia studies in affording indirect evidence for the existence of this second locus of action of vitamin B_{12} in animal metabolism.

The results with higher odd-carbon straight chain acids, heptanoic and nonanoic, although not as clear-cut as the previous findings with valeric acid, strongly suggest that vitamin B_{12} is required in their metabolism. Similar indications were obtained for the involvement of vitamin B_{12} in the course of metabolism of the branched chain 4-methylvaleric acid, which would be expected to give rise, in its initial degradation, to isobutyric acid. As pointed out previously, this latter acid was found to require vitamin B_{12} during its catabolism.

On the other hand, as with acetic and butyric acids, the findings with the higher even-carbon straight chain acids, hexanoic (caproid), octanoic, and decanoic, gave no indication of the involvement of vitamin B_{12} in the course of their metabolism. Similar results with higher levels of lactic acid confirmed the previous findings in affording no evidence for any connection between vitamin B_{12} and the metabolism of this acid. (AH h4-3)

2. Effect of ration on B_{12} and B_{12} analogues produced in the rumen. The cow obtains its supply of vitamin B_{12}, either predominantly or solely, through synthesis by the microflora of the rumen. Vitamin B_{12} analogues, which are inactive for the animal but which may be of importance in the normal metabolism of the flora themselves, are produced at the same time. Variations in the rumen synthesis of vitamin B_{12} and its analogues due to differences in the ration of the cow have been investigated by microbiological assay. Two experiments bearing upon this problem have been carried out. In the first experiment, samples of rumen contents were obtained from cows fed one of four diets--chopped hay, finely ground pelleted hay, a hay and grain mixture, and silage. In the second experiment, the cows were fed silage or hay, either ad libitum or restricted. Since none of the samples have been completely analyzed, the following conclusions are tentative.

The vitamin B_{12} activity, including analogues of the rumen contents of cows fed silage, was 2 to 5 times greater than those of the rumen contents of cows fed the other rations. The activities of the rumen contents of cows fed chopped hay or pelleted hay were intermediate, with apparently no real difference between the two. Apparent synthesis of the vitamin was least in the rumens of cows fed the hay-grain mixture. Restriction of the food intake seemed to have little or no effect, as compared to ad libitum feeding, when silage or hay was fed. Samples collected one hour after feeding tended to be the least potent, those collected 2 1/2 hours after feeding to be of intermediate potency and those collected 5 1/2 hours or 10 hours after feeding to be the most potent, with no real difference existing between the last two. Samples taken from the dorsal part of the rumen contained higher vitamin B_{12} concentrations than those taken from the ventral part of the rumen or the reticulum, but the differences disappear when the results are expressed on a dry matter basis.

Tests on the same samples by two methods gave essentially the same results for cows fed pelleted hay, chopped hay, or hay-grain, but differed when silage was fed, possibly indicating that the rumen contents of cows fed the latter ration contained somewhat different proportions of the various vitamin B_{12} analogues than did the rumen contents of cows fed the other diets. Results with a third test indicated about the same ratio of animal active vitamin B_{12} to total B_{12} activity in the rumen contents regardless of the ration fed.

Analysis of samples of the dietary constituents for vitamin B_{12} activity

indicated that the higher activity of the rumen contents of the cows fed silage was very likely not due to a higher vitamin B_{12} potency of the ration. (AH h4-3)

3. Unidentified nutrients. Work has continued on a study of the still-unidentified nutrients occurring in foods and feeds by use of rats whose requirements for dietary essentials were increased by feeding them thyroprotein and thus rendering them hyperthyroid.

Mevalonic acid, a growth factor for certain microorganisms, was tested and found to be without effect on the growth of these thyroprotein fed rats.

Attempts at fractionating the unidentified growth factor (UGF) - containing material from fishmeal - were continued. All the UGF activity in the original fishmeal was contained in the residue after extraction with alcohol, ether, and acetone. Depending somewhat upon test conditions, both the filtrate and precipitate after acid hydrolysis of the fishmeal residue were active.

Little attempt was made to refine the precipitate fraction. Activity of this fraction seemed confined primarily to tests in which the basal ration did not contain any dried whole liver. Thus, the evidence suggested that this fraction contained a substance which acted similarly to liver.

Activity of the filtrate fraction was not affected greatly by the presence or absence of dried liver in the test ration. The most purified preparation of this fraction obtained thus far, consisting of 0.16% of the weight of the original fishmeal and fed in the ration at a rate of 2.2 milligrams per 100 grams ration (approximate daily intake), appeared to be somewhat active but not to contain full activity. There were several indications that the stability of the UGF activity was considerably diminished when it was freed from the material to which it was originally bound.

Experiments were carried out bearing upon the question of whether the UGF-containing food substances are active only for hyperthyroid rats or whether the activity is more general in nature. When rats were fed a 20% fat ration not containing thyroprotein, their growth rate was slightly increased by the inclusion of fishmeal in the diet. The differences observed were not large, but were in agreement with the concept that fishmeal contains factors beneficial to the normal animal as well as to rats rendered hyperthyroid by the feeding of thyroprotein.

Reports in the literature indicate that commercial haemoglobin is among the most active of the naturally occurring substances for the "liver residue antithyrotoxic factor." Tests showed that it possesses all the activity of dried whole liver but probably not all that of fishmeal, although further experiments are needed to determine the latter point conclusively. (AH h4-1)

D. Rumen Function

This work primarily relates to studies on rumen microbiology and metabolism in cattle. It is largely basic in nature but is also pertinent to work on the nutritional efficiency of cattle. (AH h2-3)

1. Methanogenic bacteria. Because of the great importance of these bacteria in the rumen fermentation and because very little is known concerning their nutritional and biochemical characteristics, due to the great difficulty of pure culturing them, studies were initiated to attempt their isolation and characterization. In studies on their isolation, colony counts and measurement of methane produced indicated numbers of 10^8 to 10^9 per ml of rumen fluid. Based on morphology and colony type, only one species, Methanobacterium ruminantium, was detected. One strain was pure cultured and has been maintained for 10 months. In studies on energy sources utilized for growth, CO_2 appears to be required as the hydrogen acceptor. No other compounds will replace it in growth experiments. Either hydrogen gas or formate will serve as the hydrogen donor and no other active hydrogen donors have been found among many compounds tested. Studies by Smith and Hungate, the only workers who previously were able to isolate the bacterium, suggested it had a growth requirement for a "rumen fluid" factor. In nutritional studies we have been able to grow the organism in purified media devoid of rumen fluid and containing H_2, CO_2, formate, minerals, volatile fatty acids, heme, B-vitamins, vitamin-free casein hydrolysate, agar, and sulfide. Simple routine methods for obtaining good cell crops have not yet been perfected so that definitive nutritional studies can be carried out; however, a definite requirement for acetate was established and the B-vitamin mixture, molybdate and protein hydrolysate were stimulatory. Rumen volatile fatty acids, other than acetate, were not required.

2. Growth requirements of bacteroides ruminicola. Previous studies indicated that most species of rumen bacteria do not require amino acids for growth and will grow with NH_3 as the main nitrogen source. Many require NH_3 for growth and are very inefficient in using exogenous free amino acids as a nitrogen and carbon source for protein synthesis. However, strains of B. ruminicola, one of the most numerous species, were shown to require or to be highly stimulated by factors in enzymatic hydrolysate of casein, did not require NH_3 when the latter was present, but were very inefficient in using exogenous free amino acids for protein synthesis. Studies on the nitrogen requirements have now shown that casein hydrolysate can be replaced by mixtures of cysteine, methionine, and ammonia. Under these conditions, both ammonia and methionine are required. None of 81 single nitrogen compounds, including amino acids, urea and urea derivatives, amides, amines, purines, pyrimidines, glutathione or dipeptides, or mixtures of free amino acids similar to those in casein or acid hydrolyzed casein would replace the NH_3 requirement. A study of fractions of enzymatic hydrolysate of casein showed that peptides and especially the longer chained

peptides very efficiently replaced the NH_3 requirement and most of the amino acid nitrogen in the peptides was utilized. Unhydrolyzed casein, but not several other proteins, also efficiently replaced the NH_3 requirement. A search for peptides of known structure which would replace the NH_3 revealed that oxytocin, a peptide containing nine amino acids, was very active. The results add further weight to the idea that NH_3 nitrogen is relatively more important in protein synthesis by rumen bacteria than free amino acids and that peptide nitrogen but not free amino acid nitrogen is also efficiently used by one species. The methionine requirement for growth of some strains of B. ruminicola is one of only a few instances of an authenticated amino acid requirement among functional rumen bacteria. As previous studies indicated that this bacterium was very active in NH_3 production from protein hydrolysates, the present results also suggest that peptides may be relatively more important than free amino acids as the final extracellular precursors of NH_3 resulting from protein digestion by bacteria in the rumen.

3. Ecology of rumen bacteria. Cooperative studies with workers at Montana State College indicate that similar numbers are cultured and many of the same species of predominant bacteria are present in the rumen of elk on winter range and in cattle. Cooperative studies with workers at the National Institute for Research in Dairying, Shinfield, England, showed that culture methods used for total bacterial colony counts and most probable numbers of cellulolytic bacteria in rumen contents were useful in studies on the guinea pig caecum. Counts of both total and cellulolytic bacteria in the caecum were similar to those in the rumen and cellulolytic bacteria and spirochetes similar to species in the rumen were isolated from the caecum. These studies indicate that some rumen bacterial species are more widely distributed in nature than has been generally realized.

E. The Metabolism of Zinc. Research was continued at Madrid, Spain, under PL 480 to study the metabolism and excretion of zinc in animals. Male or female dogs six months to five years of age were maintained in metabolism cages and injected intraperitoneally with isotonic $Zn^{65}Cl_2$ at the rate of 100 µc per kg. body weight per day. The duration of the injection periods were 10, 20, 35 or 45 days. The specific activity of the radionuclide solution was 0.58 µc per mg. The following changes in the formed elements of the blood were observed: (1) A transitory anemia, from which dogs injected for a shorter duration, or younger dogs, recovered more quickly; (2) a transitory (6 to 10 days) leucopenia, followed by a leucocytosis and a gradual return to normal leucocyte numbers; (3) a lymphopenia, and a gradual return to normal values; (4) an increase of neutrophyls; (5) a slight eosinopenia; (6) no effect on basophils or monocytes; (7) a transitory thrombopenia, followed by a gradual recovery to normal thrombocyte levels. With increasing dosage of the radionuclide, there was an increase in erythrocyte fragility and sedimentation rate. There was no effect after 20 days on clotting time.

Two experiments were performed using guinea pigs. In the first, 100 μc per kg. body weight of $Zn^{65}Cl_2$ in isotonic solution was given intraperitonally to eight-week old animals of either sex maintained in metabolism cages; the distribution of radioactivity in tissue was determined at intervals of 1, 3, 5, 7, 15 or 30 days. In the second experiment, 20 μc of the radionuclide per kg. body weight was given per day for 10 days either intramuscularly or intraperitoneally to 12-week old animals of either sex; all animals were sacrificed on the 10th day.

Organs and tissues were grouped into four categories on their rates of assimilation and disassimilation of radioactivity: (1) Assimilation and disassimilation both rapid - pancreas, kidney, liver, heart and small intestine; (2) assimilation more rapid than disassimilation - spleen, ovary, adrenal, large intestine, lung, stomach; (3) low rates of assimilation and disassimilation- muscle, testicle, bone, cerebrum; (4) slow assimilation and very slow disassimilation - hair. Fecal loss of radioactivity was greater than urinary loss, and excretory loss was greater from intraperitoneal than from intramuscular administration. Total excretory loss was greater in females than males. (E-25-AH-4)

F. Fish Silage. Studies on the nutritional value of fish silage produced by yeast fermentation were initiated in Uruguay with PL 480 funds. The current year's findings indicated that after fermentation is finished, there was no variation in N content of trimethylamine, no production of H_2S and only .03% free ammonia (Nessler reaction) production. (S9-AH-1)

G. Effect of Heat Stress on Blood and Urine Constituents of Sheep. Groups of yearling weathers were used to study the effect of 2 week exposure periods to ambient temperatures of 70, 85 and 95° F. on various blood and urine components. Both the 85 and 95° temperatures brought about significant increases in rectal temperature, skin temperature, respiration rate and water consumption, while the changes in the blood and urine components were for the most part quite variable under the heat stress condition. Hematocrit showed little change at 85° conditions but there was a significant decrease at 95° F. Hemoglobin values were quite variable at 70 and 85° but there appeared to be some decrease at 95°. Urine volume showed little change at 70° and 85° but increased significantly at 95°. At 85° and 95° urine specific gravity was decreased to a significant degree but the changes in total nitrogen, urea nitrogen, uric acid, creatinine and creatine in urine showed little relationship to the ambient temperature conditions. The same constituents of blood also failed to show any trends consistent with the ambient temperature conditions. Although a number of the correlations between water consumption, rectal temperature, skin temperature, respiration rate and the blood and urine components studied were significant, they were of a low order (-.3 to +.3). The results indicate changes in blood and urine components of sheep are minor and highly variable at elevated air temperatures. (AH-g4-1)

H. Radioactive Fallout

1. Protection of milk against I^{131}. The effectiveness of feeding dairy cows uncontaminated or stored feed as a means of preventing iodine 131 from gaining entrance into the milk has been studied by the Department in cooperation with the Department of Health, Education and Welfare and the Agricultural Experiment Stations of Minnesota, Iowa, and Utah.

These studies showed that:

(a) The removal of cows from pasture and feeding stored feed is an extremely effective means of reducing iodine 131 levels of milk.

(b) At the levels encountered in this study, inhalation and direct contact are insignificant sources of iodine 131 in milk.

(c) Iodine 131 in milk is reduced to insignificant levels within three or four days after the cows are removed from a contaminated pasture and, conversely, iodine 131 in milk approaches its maximum level in milk within three or four days after cows are placed on a contaminated pasture.

Thus, in periods of significant fallout of iodine 131 from the atmosphere, the contamination of milk by this radionuclide can be avoided or reduced to very low levels in a short time by removing lactating cows from a pasturage-feeding system and placing them on stored feed rations.

2. Effects of whole body irradiation and ingestion on health and metabolism of farm animals. Preliminary studies have been carried out to establish procedures for the accurate measurement of radiation exposure to various tissues. Air dose distribution within the 32 feet diameter exposure room has been determined for various combinations of the eight 100 curie cobalt-60 sources. A range in dose rates from 3 to 2500 r per hour is available. With optimal placement, the surface dose rate to cattle varies from 59 to 115 r per hour and to goats, from 84 to 120 r per hour.

Internal distribution from external exposure was first evaluated in a woodwater goat phantom and then in two dead cattle and one dead goat. From the results, procedures have been established which accurately estimate the exposure dose at the surface and within the animal at any points desired. Surface dose measurements have been made on 6 cattle and 4 goats. The results indicated symmetry of exposure and repeatedly gave a similar pattern of exposure from one portion of the body to another. The dose rates were the same as those determined in the dead animal studies.

Six cows have been exposed to gamma radiation at dosages of 450, 600, and 1000 r. Four goats have been exposed to dosages of 200, 450, 800, and

1000 r. The general health of cows which received 450 or 600 r and goats which received 200 or 450 r remained good. Feed and water consumption and milk production decreased moderately but returned to normal within a few days. Milk composition remained normal except when there was decreased secretion. The percentage of a daily dose of Sr-85, I-131, and Cs-137 that appeared in milk increased temporarily following irradiation. An initial body temperature rise of 2° to 4° F. was observed within 12 hours after irradiation of cows and goats but soon returned to normal. With the exception of the goat exposed to 200 r, marked leukopenia occurred in animals within 2 days. Moderate leukopenia still existed in cows and goats 6 months after irradiation. The animals that received higher dosages died 16 to 19 days after irradiation. Post mortem examination of animals that died revealed massive internal hemorrhages. Tissue samples have been taken for histological examination.

This work was cooperative with the New York Agricultural Experiment Station. (AH h2-10)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Genetics

Kyle, W. H. and Goodale, H. D. 1963. Selection progress toward an absolute limit for amount of white hair on mice. Prc . XI International Congress of Genetics. In press. (Pioneering Res. Lab.)

Reckel, R. P. and Scheinberg, S. L. 1963. *In vitro* uptake of Fe^{59} in adult and immature avian and human red cells. J Poultry Science 42(3) 595-598. (Pioneering Res. Lab.)

Scheinberg, S. L. 1962. Somatic variation of red cell antigens. Proceedings of the 11th Annual Agricultural Research Institute, National Res. Council, Nat. Acad. Sci. 75-83. (Pioneering Res. Lab.)

Scheinberg, S. L. and Wong, D. T. O. 1963. Properties of the *Phaseolus lunatus* lectin. Abstr. Fed. Proc. 22(2) part 1, 381. (Pioneering Res. Lab.)

Wong, D. T. O. and Scheinberg, S. L. 1962. Studies of the agglutinins reactive with human A red cells. Abstr. IX Int. Congress of the International Soc. of Blood Transfusion. 71-72. (Pioneering Res. Lab.)

Wong, D. T. O. and Scheinberg, S. L. 1963. Studies of the anti-A hemagglutinins from *Phaseolus lunatus* and human serum. The Immunogenetics Letter 3(1) 46-67. (Pioneering Res. Lab.)

Wong, D. T. O. and Scheinberg, S. L. 1963. Studies of the agglutinins reactive with human A red cells. IX Int. Congress of the Int. Soc. of Blood Transfusions. In press. (Pioneering Res. Lab.)

Physiology

Cecil, H. C., Bitman, J., Connolly, M. R. and Wrenn, T. R. 1962. Glycogen in the decidual tissue of the rat uterus. J. Endocrinology 25, pp. 69-76. (AH h5-8)

Cecil, Helene C., Wrenn, T. Randall and Bitman, Joel. 1962. Uterine histamine in rat deciduomata. Endocrinology 71, pp. 960-963. (AH h5-8)

Connolly, Mary E., Bitman, Joel, Cecil, Helene C., and Wrenn, T. Randall. 1962. Water, electrolyte, glycogen, and histamine content of rat uterus during pregnancy. Am. J. Physiol. 203, pp. 717-719. (AH h5-8)

Domenski, E., and Mazurczak, J. 1962. A new surgical method of the pituitary stalk section in sheep in neurcendocrine investigations. 22nd International Congress of Physiological Sciences, Leiden, Netherlands. Sept. 10-17, 1962. (E21-AH-1)

Domenski, E. and Mazurczak, J. 1963. Methods of investigating the function of the hypothalamus and hypophysis in chronic experiments with sheep. Acta Physiologica Polonica. (E21-AH-1)

Hawk, H. W., Brinsfield, T. H., Turner, G. D., Whitmore, G. E., and Norcross, M. A. 1963. Effect of ovarian status on the acute inflammatory response in cattle uteri. J. Dairy Sci. 46 p. (Abstract) (AH h5-8)

Hawk, H. W., Righter, H. F., and Brinsfield, T. H. 1963. Effect of ovarian status on the acute response to inflammatory stimuli in the mammary gland of the ewe. Am. J. Vet. Res., 24 pp. 428-434. (AH h5-1)

Hawk, H. W., Turner, G. D., and Brinsfield, T. H. 1963. Effect of heparin on hormonal control of leukocytic emigration in the rabbit uterus. Am. J. Vet. Res., 24 pp. 352-354. (AH h5-8)

Hawk, H. W., Turner, G. D., and Brinsfield, T. H. 1963. Endocrine control of vascular permeability and induced leukocytic emigration in the rabbit uterus. Am. J. Vet. Res. 24, pp. 595-601. (AH h5-8)

Lucas, A. M. 1962. The gross and microscopic structure of the avian respiratory system and its reactivity to stimuli. Poultry Disease Training Program, National Animal Disease Laboratory, Ames, Iowa. Mimeograph, 12 pages. (AH e6-26)

McKee, G. S., Lucas, A. M., Denington, E. M., and Love, F. C. 1963. Separation of leukotic and non-leukotic lesions in turkeys on the inspection line. Avian Diseases 7: 19-30. (AH e6-20)

Menge, A. C., Tyler, W. J., and Casida, L. E. 1962. Factors affecting the removal of spermatozoa from the rabbit uterus. J. Reprod. Fertil. 3:396. (AH h5-6)

Menge, A. C., Stone, W. H., Tyler, W. J., and Casida, L. E. 1962. Immunological studies on fertility and sterility. IV. Fertility of cattle and rabbits inseminated with semen treated with antibodies produced against semen, spermatozoa and erythrocytes. J. Reprod. Fertil. 3:331. (AH h5-6)

Menge, A. C., Kiddy, C. A., Stone, W. H., and Casida, L. E. 1962. Immunological studies on fertility and sterility. V. Effect of antibodies against semen and erythrocytes on rabbit embryos. J. Reprod. Fertil. 4:87. (AH h5-6)

Righter, H. F., Brinsfield, T. H., and Hawk, H. W. 1962. Vascular permeability in uterus and mammary gland of the ewe. J. Animal Sci. 21, p. 1029 (Abstract) (AH h5-1)

Righter, H. F., Hawk, H. W., and Brinsfield, T. H. 1963. Effect of experimental inflammation on vascular permeability in the mammary gland of the ewe. Am. J. Vet. Res. 24, pp. 435-438. (AH h5-1)

Schmidt, G. H., Chatterton, Jr., R. T., and Hansel, W. 1962. Histological changes during involution of mammary glands of ovariectomized and intact lactating goats. J. Dairy Sci., 45:1380-1382. (AH h5-3)
Wrenn, T. Randall, Cecil, Helene C., Connolly, Mary R., and Bitman, Joel. 1962. Ionic studies of decidual tissue growth in the rat uterus. Acta Endocrinologica 40, pp. 472-480. (AH h5-8)

Nutrition

Dryden, L. P., Hartman, A. M., Bryant, M. P., Robinson, I. M., and Moore, L. A. 1962. Production of B_{12} and vitamin B_{12} analogues by pure cultures of ruminal bacteria. Nature (London) 195:201-202. (AH h4-3)
Hartman, A. M., and Dryden, L. P. 1962. Vitamin B_{12} and the metabolism of rumen fatty acids. J. Dairy Sci. 45:691 (Abstract) (AH h4-3)

Rumen Function

Allison, M. J. and Bryant, M. P. 1963. The biosynthesis of branched-chain amino acids from branched-chain fatty acids by rumen bacteria. Arch. Biochem. 101, pp. 269-275. (AH h2-3)
Allison, M. J. and Bryant, M. P. 1962. On the biosynthesis of branched-chain amino acids by Ruminococcus flavefaciens. Proc. Eighth International Congress Microbiol. p. 42 (Abstract) (AH h2-3)
Bryant, M. P. and Robinson, I. M. 1962. The utilization of ammonia and amino acids by growing cultures of predominant species of ruminal bacteria. Proc. Eighth International Congress Microbiol. p. 42. (Abstract) (AH h2-3)
Bryant, M. P. and Robinson, I. M. 1962. Some nutritional characteristics of predominant culturable ruminal bacteria. J. Bacteriol. 84, pp. 605-614. (AH h2-3)
Bryant, M. P. and Robinson, I. M. 1963. Apparent incorporation of ammonia and amino acid carbon during growth of selected species of ruminal bacteria. J. Dairy Sci. 46, pp. 150-154. (AH h2-3)
Pittman, K. A. and Bryant, M. P. 1963. Nitrogen sources for growth of Bacteroides ruminicola. Bacteriol. Proc. p. 8. (Abstract) (AH h2-3)
White, D. C.,Bryant, M. P., and Caldwell, D. R. 1962. Cytochrome linked fermentation in a saccharolytic ruminal anaerobe. Proc. Eighth International Congress Microbiol. p. 42. (Abstract) (AH h2-3)
White, D. C., Bryant, M. P., and Caldwell, D. R. 1962. Cytochrome-linked fermentation in Bacteroides ruminicola. J. Bacteriol. 84, pp. 822-828. (AH h2-3)

AREA NO. 2: BEEF CATTLE -- BREEDING

Problem. Expression of each of the productive and carcass traits of beef cattle varies from breed to breed and between animals within each breed. The beef cattle producer is constantly striving to achieve excellence in one or more of these traits. Frequently his failure to choose the best animals for breeding stock for the most effective mating program results in less than maximum progress. Often the beef cattle producer does not know how to identify, evaluate and utilize the existing variability to achieve his aim. Research information is needed on heritability of economic traits in beef cattle, genetic and phenotypic correlation between these traits, effectiveness of various selection and breeding programs, and assessment of traits most useful in beef cattle improvement.

USDA PROGRAM

The beef cattle breeding research in the United States has developed as a coordinated program of the USDA and the State Experiment Stations. It is a continuing program of both applied and basic research carried on by geneticists, animal physiologists, and animal husbandmen. Early efforts in the improvement of beef cattle through performance testing were made by the USDA at Miles City, Montana, and Beltsville, Maryland. With the advent of regional research, efforts by the State stations were greatly increased and the individual programs were coordinated through regional research projects in three of the important beef cattle producing regions. This joint activity has been and remains characteristic of beef cattle breeding research, and the resulting program is an integrated effort combining to the best advantage the resources of the State Experiment Stations and the USDA.

The regional project in the South is S-10, Improvement of Beef Cattle for the Southern Region through Breeding Methods. Much of this region is subtropical in climate and in many cases cattle used in other areas are poorly adapted. Environmental conditions adversely affecting survival, reproductive regularity and growth are encountered. Research includes projects at 13 State stations and at the USDA stations at Jeanerette, Louisiana; Front Royal, Virginia; and Brooksville, Florida.

In the Western region the beef industry is largely geared to range conditions with many cattle shipped to areas of abundant grain supply for fattening. Ability to make maximum use of forage available on the range is an important consideration. These problems are studied through regional project W-1, The Improvement of Beef Cattle through the Application of Breeding Methods. Research includes projects at 12 State stations and at the USDA station at Miles City, Montana.

Similarly, NC-1, Improvement of Beef Cattle through Breeding Methods, is geared to problems of the beef industry in the North Central region where beef is produced on farms with pastures of high productivity and ample grain supplies for feedlot finishing. Research includes projects at 12 State stations and at the USDA stations at Fort Robinson, Nebraska, and Fort Reno, Oklahoma.

The Federal scientific effort devoted to research in this area totals 17.5 professional man years. Of this number, 1.3 are devoted to performance testing, 4.7 to genetics and interrelations of performance traits, 1.0 to genetic-environmental interactions, 7.8 to selection and systems of breeding, and 2.7 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelationships of Performance Traits

1. Growth rate and efficiency of gain. In the most comprehensive study yet made on the genetic aspects of efficiency of gain (defined as live-weight gain in relation to feed consumed), data on over 1300 animals individually fed showed efficiency of gain to be 62% heritable when adjustments were made for differences in live weight and in feed consumption. Heritability of feed consumption was 64%. Genetic correlations were: growth rate and efficiency of gain, .8; growth rate and feed consumption, .6; and feed consumption and efficiency of gain, zero. This indicates that selection for growth rate will result in improved efficiency of gain with a part of the improvement being due to true improvement in efficiency and part to increased feed consumption. Increased feed consumption increases rate of gain and indirectly increases efficiency of gain through reducing overhead cost of maintenance per unit of gain. (AH d1-12, d1-31)

Several other studies have shown positive genetic relationships between rate and efficiency of gain with the magnitude of the relationship varying considerably between studies. (AH d1-8, d1-22)

The results of these studies, as well as related studies with other species, indicate that selection for high levels of overall productivity is the most potent tool available for increasing net production of the beef industry in relation to feed consumption. However, much more information than now available is needed on variation between individual animals in maintenance requirements.

Data from several stations, including progeny tests of high and low gaining sires, have confirmed previous estimates of high heritability of postweaning growth rate. (AH d1-29, d1-2)

In one study, heritability of growth rate tended to increase as the length of the postweaning evaluation period increased up to 550 days of age. In

general, estimates of heritability tended to be high for growth rate and conformation score at different periods. Genetic correlations of weights with conformation scores were low but tended to be positive. (AH d1-12)

Selecting for weaning conformation score would be expected to be about .88 as efficient as 550-day score itself in changing genotype for 550-day score. For bulls the correlations of 396-day and 550-day score with genotype for 550-day score were equal. These results indicate that the genetic factors affecting conformation score taken at different ages are to a large extent the same. (AH d1-12)

Correlations of the phenotypes for weight at various ages with the genotype for 550-day weight indicate that some measure of postweaning gain should be included with weaning weight in predicting the genotype for 550-day weight. The pooled estimates suggest that 200 and 396 day weights would be .52 and .81 as efficient, respectively, as 550-day weight itself in selecting for 550-day weight. (AH d1-12)

Another study demonstrated that heritability estimates for growth in yearling cattle were appreciably higher than estimates obtained in early stages of life. Selecting for growth based on the preweaning data would be approximately one-third as effective as direct selection for growth in yearling cattle. (AH d1-14)

Studies continued on physiological characters as possible indicators of potential productivity. In one study, blood components were found to be not consistently correlated with production traits. It is interesting to note that at 500 and 700 pounds body weight, urea nitrogen was significantly negatively correlated with rate of gain but positively correlated with feed per unit of gain. (AH d1-19)

Another study on blood components showed a significant correlation between plasma fat and age of calf. However, correlations between other blood values and initial weight, test gain, final weight, feed efficiency, and final score were nonsignificant. (AH d1-36)

Thyroid secretion rate was estimated in a population of cattle using the I^{131} method. There were no differences between sire groups in thyroid secretion rate and the correlation between growth rate and thyroid secretion rate was negligible. The relationship between blood glucose and certain non-sugar reducing substances in the blood with growth rate was not high enough to have predictive value for estimating differences in growth rate.

2. Carcass characteristics. Results continue to show high heritability estimates for many important carcass traits. The greatest problem in effecting genetic improvement is that of estimating carcass characteristics in living animals so that the costly and time-consuming step of progeny

testing can be eliminated. Work on this problem and evaluation techniques on carcasses themselves, will be given in the section on performance testing.

An analysis of steer data involving over 600 head fed during a ten-year period was published and indicated only low and generally insignificant genetic relationships between most carcass characters and production traits. (AH d1-2)

Data from another study indicate that a larger rib-eye area is associated with faster gains and larger size, but is not associated with improved feed conversion, type, increased yield of higher-priced wholesale cuts, or improved eating quality. Correlations between feed conversion and wholesale cut weights and yields were low or negative, as were correlations between performance records and taste-panel scores. (AH d1-8)

While the results are preliminary, there are some indications of a positive genetic correlation between growth rate and carcass fatness. More research is needed in this area but such a relationship seems possible on the basis of appetite phenomena. (AH d1-12)

These studies, as well as others in previous years, indicate that, except when the carcass traits are connected in some way with size, genetic correlations between carcass traits and live production traits are low.

In a comparison of seven breeds and three types - beef type, dairy type, and zebu type - loin steaks from dairy type steers were most tender when evaluated by a Warner-Bratzler shear machine. Most of the advantage in the dairy type was contributed by the Jersey breed, which seemed to be quite tender, both as evaluated by shearing and on a tenderness score evaluated by a panel. However, Jersey steers were least efficient on production, next to lowest on daily gains, and produced the poorest carcass yields. Holstein steers on the same test had the highest daily gains, with the highest feed efficiency, and produced carcasses with high cutting yields. They were average among breeds in eating quality. The Brahmans had a higher percent of separable muscle, but had poor feedlot performance and ranked at the bottom on palatability scores. Santa Gertrudis and Brahman crosses had acceptable gains, feed conversion, and carcass cutability, but were usually ranked next to Brahmans on palatability score. Angus carcasses graded highest of all, but had low cutting yields, largely due to a higher percent of fat. Hereford carcasses had higher cutting yields and were graded slightly higher than Angus on palatability, despite a significantly lower carcass grade and degree of marbling. Both British breeds were above average in palatability. (AH d1-9)

3. Reproductive phenomena. Fertility and its components have generally been shown to be low in heritability but fertility is undoubtedly the single, most important problem of the beef cattle industry. A four-year summary of most herds in the Southern Regional Project, involving several thousand cow years, showed that 77% of cows bred calved and 72% raised calves. Weaning percentage varied among States from 64% to 88%. Industry statistics for the

same area are not available, but indications are that the reproductive rates in experiment station's herds are indicative of industry levels.

In spite of low heritability, breed differences have been observed in the South in reproductive rates with British breeds (Angus, Hereford, and Shorthorn) generally having higher calving percentages than pure Zebu breeds or breeds with Zebu blood (Brahman, Brangus, Santa Gertrudis). The three British breeds studied had a higher conception rate when they were nursing a calf when bred, while the three Zebu breeds had the highest conception rate when they were dry during the breeding season.

4. Sexual maturity. The age at which heifers first come into heat has been studied for different breeds. Of four straight-breds studied - Angus, Hereford, Brangus, and Brahman - the Angus, on the average, came in heat earlier, followed by Hereford, Brangus, and Brahman, respectively. Among backcross heifers, three-quarter Shorthorn heifers reached puberty earlier than three-quarter Angus, three-quarter Hereford, three-quarter Brangus, three-quarter Charolaise, and three-quarter Brahman. No heterosis has been noted for age of puberty in either of these studies. (AH d1-6)

Age of puberty has been determined at the Iberia Station for heifers of Angus, Brangus, Brahman, and Africander-Angus breeding using sterile teaser or fertile bulls painted with a grease paint pigment mixture. Crossbred heifers fed a fattening ration are also checked for age at puberty using sterile males during the drylot fattening period for 168 days. Angus heifers reached puberty at a younger age than heifers of the other breeds studied. The Brangus and Africander-Angus were intermediate while the Brahmans were oldest at time of sexual maturity. None of the Brahmans born in 1960 had shown heat at two years of age while nearly all heifers of other breeds had reached sexual maturity. The first cross (AXB) (BXA) heifers reached puberty at an earlier age due to a faster growth rate than heifers of other breeds. Angus-sired crossbred heifer calves reached puberty at a consistently younger age than crossbred calves sired by Brahman or Brangus bulls, when fed a fattening ration for 168 days. (AH d1-30)

Age and weight at puberty were determined in 49 straightbred and 54 crossbred heifers at Fort Robinson. These heifers represented progeny for Angus, Hereford, and Shorthorn sires mated to cows of their own breed and to cows of the two other breeds. Heifers were wintered on native grass with one pound of cake. The average age at puberty was 415 days for straightbred heifers and 380 days for crossbred heifers. Average weight at puberty was 525 and 530 pounds for straightbred and crossbred heifers, respectively. The average age and weight were 444 days and 574 pounds; 405 days and 513 pounds; 395 days and 489 pounds for Hereford, Angus and Shorthorn heifers, respectively. (AH d1-37)

At Miles City, studies on age and weight at sexual maturity in both heifers and bulls are being conducted. Bulls and heifers represent the Hereford, Angus, and Charolaise breeds. In addition, crossbred and reciprocal cross-

bred animals resulting from the interbreed mating of these three breeds and crossbreds from matings of Hereford, Angus, and Charolaise bulls on Brown Swiss cows are also being studied. The study involves 83 heifers, of which 25 are straightbred and 58 are crossbreds. In the heifers, 92 percent of the straightbreds and 95 percent of the crossbreds have exhibited estrus. Average age at first estrus was 355 days for both straight and crossbreds and average weight at first estrus was 625 and 629 pounds for straight and crossbreds, respectively. Age and weight of heifers classified by breed of sire was 365 days and 630 pounds, 346 days and 595 pounds and 346 days and 660 pounds for Hereford, Angus, and Charolaise sires, respectively.

Age at puberty has been determined in 21 straightbred and crossbred bulls. All bulls are subjected to electroejaculation at 28-day intervals and the ejaculate examined microscopically for the presence, motility, and concentration of sperm. Fourteen days after electroejaculation and again at 28-day intervals all bulls are exposed to an estrogen treated heifer and breeding ability determined and a libido score given.

To date all bulls have reached puberty except one straightbred Charolaise. Crossbred bulls have reached electroejaculation classification criteria earlier than straightbreds as shown by the following averages. Age (days) for purebreds vs. crossbreds at: appearance of sperm, 243 vs. 228; appearance of motile sperm, 285 vs. 248; appearance of sperm numbers sufficient for detailed classification, 276 vs. 260; and first definite ejaculation; 313 vs. 288, straightbreds vs. crossbreds, respectively. In breeding ability data, average puberty age and libido scores were 375 days and 3.0 vs. 355 days and 3.2 for straightbreds vs. crossbreds, respectively. (AH d1-33)

Variation of milk production between and within breeds is being studied. There is additional evidence that a significant relationship exists between milk production of the dam and calf gains. A study at the Texas station has shown no noticeable decline in milk production through the lactation period in beef cows, as has been reported in dairy cows. This station also reports that milk yields within breed vary from slightly less than two pounds to more than 18 pounds of milk during mid-lactation. These data come from some 400 cows of Angus, Brahman, Hereford, Shorthorn, Santa Gertrudis, half-Brahman, half-Hereford, and half-Charolaise breeding. In a comparison of breeds at the Jeanerette station, Brangus cows yielded more milk - followed by Angus, Africander-Angus, and Brahman, respectively. (AH d1-6, d1-22, d1-29)

5. Reproductive rates in breeding herds. Results from the 1962 breeding season at Fort Robinson show that cows being bred for straightbred calves had slightly superior reproductive performance as compared to cows being bred for crossbred calves. These results are not consistent with the results obtained during the past three years. The proportion diagnosed pregnant was 95% for cows bred for straightbred calves versus 93% for cows bred for crossbred calves. Little difference was noted in the number of services required per conception or the percent settling at first service.

A comparison between reproductive performance of crossbred and straightbred cows, both bred for crossbred calves, has also been obtained this past year. The proportion of cows pregnant was 97% for crossbred cows versus 90% for straightbred cows. Fewer services per conception (2.00 vs. 1.76) were required by the crossbred cows and more settled on first service (60% vs. 57%). The embryonic mortality was much higher in straightbred cows than in the crossbred cows (15% vs. 3%). The proportion of crossbred cows giving birth to a calf was 93% vs. 77% for the straightbred cows. (AH d1-37)

The pregnancy rate of the breeding herd for 1962 at Jeanerette was about average with pregnancy rates of previous years but was much lower than for 1961. The proportion of the cows pregnant was 87, 63, 65, 72, and 100 percent for the Angus, Brangus, Brahman, Africander-Angus, and first cross (AXB) (BXA) cows, respectively. Two-year-old heifers had a higher fertility rate (79% pregnant) than three-year-old (59% pregnant) or older cows (73% pregnant). Only 27 and 33 percent of the three-year-old Brangus and Brahman heifers bred, were diagnosed pregnant compared to percentages of 67 and 86 for the Africander-Angus and Angus, respectively.

A major cause of low fertility was lack of estrus during the 75-day breeding season. Cows not showing heat during the breeding season accounted for 37 percent of the open Brangus, 67 percent of the open Brahman, and 86 percent of the open Africander-Angus. Forty-seven percent of the open cows which showed heat had only one or two heat periods. The interval from calving to first heat was 85, 130, 200, 122, and 71 days, respectively, for Angus, Brangus, Brahman, Africander-Angus, and F_1 crossbred three-year-old lactating heifers. Older cows had shorter intervals from calving to first heat than three and four-year-old cows. Intervals from calving to first breeding and to conception were longer for cows with Zebu breeding than Angus cows.

The proportion of cows which conceived was 60%, 51%, 21%, and 21% for first through fourth services, respectively. Of the cows which settled during the breeding season, 96.3% did so the first 64 days. There would appear to be little merit in breeding longer than this time. The number of heat periods previous to breeding appeared to influence conception rate. The proportion pregnant was 52, 60, 70, and 50% for cows bred at their first, second, third, or fourth heat period, respectively. (AH d1-30)

6. Genetic-environmental interactions. The interregional project involving selection of originally similar base stocks in two different environments (Miles City, Mont., and Brooksville, Fla.) has progressed with the final cattle transfers for setting up the base herds scheduled for the fall of 1963. To date, cattle from each location have apparently adapted reasonably well to the other within a few months to a year. (AH d1-41)

A study in which possible differential response of sire progenies was studied when heifers were fed limited grain rations on pasture and bulls full-fed in drylot showed no evidence of significant genetic-environmental interaction. (AH d1-8)

7. Genetic defects. Work continued on a reduced scale during the year on possible methods of detecting animals heterozygous for snorter-type dwarfism but with no positive results. (AH d1-9, d1-10, d1-12, d1-22, d1-31)

Work is being continued on mucopolysaccharidosis in dwarf cattle. It has been noted that matings of the Snorter dwarf bulls and cows of mixed breeding (Brahman-native) produce a ratio of dwarf to normal calves of less than 1:1. These results suggest that genes carried by animals of mixed breeding modify expression of the Snorter dwarf gene. (AH d1-34)

Greater accuracy is being achieved in recognizing specific achondroplastic types so that appropriate classifications can be made, thereby improving accuracy. These methods are a considerable improvement over visual classification. Possible reasons why certain so-called pedigree clean lines break down are being studied. There is a possible connection between dwarfism and at least certain types of hydrocephalus. A new small type of achondroplastic has been discovered which shows slender long bones, extreme curvature of the spine, and a slightly later fusion of the sphenooccipital synchondrosis. (AH d1-39)

Defects including hydrocephalus and a bulldog-type monster have occurred in inbred lines with no previous history of the production of such defects. (AH d1-2, d1-4).

B. Performance Testing

Attention to improving methods for evaluating performance in beef cattle is continuous in most projects. The most significant overall recent trends are increased attention to (1) carcass evaluation, including methods of estimating carcass characteristics from live animals, and (2) evaluation of fertility and the components or factors upon which it depends. Routine evaluations of these traits will make more comprehensive future genetic analyses possible.

1. Carcass traits. An effort has been made during the past year to collect considerable data on the use of ultrasonics as a tool in live animal carcass evaluation. Indications are that this may be a promising tool for the measurement of fat thickness in the live animal. Evidence in the past has shown that fat thickness and carcass weight make a fairly good predictive measurement of total muscle in the carcass. If a good estimate of fat thickness in the live animal could be obtained, faster progress could be made in selection for muscling. Correlations of estimated fat thickness by ultrasonic techniques with actual fat thickness taken on the carcass have ranged from a low of 0.2 to a high of 0.9. Correlations between estimated rib-eye area and actual rib-eye area, as traced on the carcass, have, in general, ranged from 0.4 to 0.7. One station has indicated that repeatability of measurement between operators seems to be quite high, while evidence from another station indicates this repeatability to be of a much lower magnitude. (AH d1-9, d1-12)

A three-dimensional photographic system known as "photogrammetry" is being studied to see if live animal photographs can be used to predict weights and proportions of wholesale cuts. In weight-variable populations the correlation between actual and predicted weights of wholesale cuts has been high but the correlation between live weight and weight of cuts has also been high leading to the conclusion that the photographic technique is an excellent indicator of size. Variability in percent of different wholesale cuts from animal to animal is relatively small and it is uncertain how well the technique can pick up proportional differences in weight-constant groups. (AH d1-2, d1-10)

In one study a correlation of .85 between predicted and actual backfat thickness was observed from use of a probe in live animals. (AH d1-20)

It is apparent that problems of technique must be solved if this procedure is to be effectively utilized by the industry.

Further study of correlations between subjective estimates of fat thickness and rib-eye area in slaughter cattle with measures of these traits in the carcass have again averaged approximately .4 to .5. The correlations between live estimates of yield of trimmed retail cuts from the round, loin, rib and chuck and actual measures by carcass cut-out have averaged approximately .5. This was among slaughter cattle of rather uniform weight and condition. While some results indicate that differences in rib-eye area are a rather poor measure of differences in muscling in the carcass, results also indicate variations in rib-eye area of considerably greater magnitude than variations in loin length. (AH d1-12)

In one study increases in length of body, depth of fat, depth of round, and carcass weight increases were linear when breed, sex, and years were held constant. Area of rib-eye tended to level off at higher weights. Therefore, carcass weight in itself gave an accurate prediction of length of body and depth of round when breed, sex, and years were held constant, but the prediction was not as high for area of rib-eye. In a study of growth of body parts, it appears that the length of some of the muscles starts leveling off at 360 days. Weight of muscles continues to increase in direct proportion to carcass weight. (AH d1-25)

2. Growth rate. A major problem of beef cattle breeding is the adjustment of preweaning records of calves for sex of calf and age of dam so that valid comparisons can be made between calves from dams of different ages and between sire progenies and different cows. If universally applicable adjustment factors could be developed, progress would be increased. However, data from several stations have shown that environmental effects have different influences on different breeds and at different locations. Similarly, age of dam effects have been found to be different in different years and, in some cases, differential age of dam effects on sex have been observed. This indicates that it is important not to use the same correlation factors regardless of breed, location, age, etc. (AH d1-6, d1-16, d1-20)

As an example of the foregoing, an analysis was made of records accumulated at one station over a period of more than 25 years and the records divided into "high" and "low" years on the basis of average weaning weights. Weights of calves from three-year-old dams were 37 pounds below those from mature dams in the low years but only 11 pounds in the high years. In this herd an adjustment system which will take year average into account appears feasible but its applicability to other areas is not known. (AH d1-6)

One study indicates that, as would be expected, cows with heavier mature weights tend to wean heavier calves. Thus, it would appear that selection for calf weights should be in relation to weight of dam. (AH d1-2).

A limited amount of data from another study indicates a curvilinear regression of weight of calf upon weight of dam. The heaviest calves were produced by cows which weighed from 1100 to 1200 pounds. Data from the same study revealed that maximum cow weight was reached at 10 to 11 years. Data on several thousand head of Santa Gertrudis cattle belonging to a private breeder revealed that the Santa Gertrudis Breeders' International classification of "S" and "S-" was found to have highly significant association with both weaning weight and weaning type. These data indicate that those factors influencing the breed classification at long yearling age also exert a significant influence on weaning performance of the offspring. (AH d1-22)

C. Selection and Systems of Breeding

1. Crossbreeding. Measures of heterosis effects involving reciprocal crosses among the Angus, Hereford and Shorthorn breeds continue to show that the crossbreds grow somewhat faster with slightly less feed required per 100 pounds of gain than the straightbreds by the same sires. The crossbreds had more fat trim (in percent) than the straightbreds at the same age; however, there was no difference in carcass grade. The crossbreds had approximately $6 advantage in net carcass value based on pounds of retail product produced (adjusted for differences in quality grade) and feed costs from weaning to slaughter. The crossbreds reached puberty at younger ages that the straightbreds. (AH d1-12)

In the southern region, analysis of data from crossbreeding experiments continues to indicate that crossbred offspring show some heterosis over the average of the parent breeds. An analysis of 180-day calf weights at one station indicated there was a substantial advantage of the crossbreds over the average of the purebreds, 15.9%. At the same station, backcross calves by crossbred dams were 18.8% heavier than the average of the purebreds. The data from this station reveal an apparent interaction between breed or cross and age of dam. Hereford, Brahman, and first-cross dams of these two breeds exhibit markedly different response curves due to age. Heterosis was also exhibited in the feedlot gains when calves were put on full feed. This heterotic effect has been shown to be as much as 11% in some cases. (AH d1-22)

Data from other stations indicate that crossbred steers were as much as 41 pounds heavier at weaning time than the parent breeds. (AH d1-29)

At several locations, work with British breed crosses has progressed to the point that preliminary information is being obtained beyond first crosses, i.e., on three-way and backcrosses. Generally speaking, the crossbred dams appear to be productive and three-breed crosses exhibit somewhat greater growth than backcrosses. (AH d1-12, d1-7)

Reproductive efficiency in first crosses between British breeds has varied between studies but, on the average, fertility has been higher in cows bred for crossbred calves than in those bred for straightbred calves. In most experiments death losses of crossbred calves have been less than of purebreds leading to an average greater net calf crop for crossbreeding. (AH d1-1, d1-3, d1-7, d1-12, d1-29)

In British-Brahman crossing tests, the crossbred cows have had marked advantages in fertility and calf survival as compared to averages of purebred parental types which, when considered in connection with the greater growth rate of their calves, resulted in about 25% more pounds of calf weaned per cow bred. The crossbred cows are also giving indications of having a longer productive life. (AH d1-22)

Crosses of the Charolaise breed with British breeds have usually resulted in considerably increased growth rates as compared to British types but in one experiment no advantages were found in Charbray - Hereford crosses. (AH d1-1, d1-40)

2. Inbreeding and linecrossing. Development of inbred lines continued at several locations with general observations being that inbreeding is usually accompanied by some reduction in fertility, livability and growth rate. In one study, estimates of line x mating system interaction indicate a greater heterosis in females. This increase in heterosis is not associated with degree of inbreeding depression. A curvilinear response to inbreeding has been demonstrated in these data. This response differed between the two sexes. Regression studies showed that inbreeding of dam has a greater effect on weaning weight than inbreeding of calf. Postweaning traits were not significantly affected by inbreeding with the exception that inbreeding of calf significantly affected yearling traits. (AH d1-2, d1-4, d1-16)

In linecrossing experiments within the Hereford breed, crossline bulls were 19 pounds heavier at weaning time than straight-line contemporary bulls. Crossline heifers were 29 pounds heavier than straight-line heifers. (AH d1-2)

Additional data show that, in general, station inbred lines developed with concurrent selection for traits of productive importance, have shown advantages in growth when top-crossed in commercial herds. (AH d1-13, d1-17)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Genetics and Interrelationships of Performance Traits

Bovard, K. P. and Hazel, L. N. 1963. Growth patterns in snorter dwarf and normal Hereford calves. J. Anim. Sci. 22: 188-196. (AH dl-35)

Brinks, J. S., Clark, R. T., Kieffer, N. M. and Quesenberry, J. R. 1962. Genetic and environmental factors affecting performance traits of Hereford bulls. J. Anim. Sci. 21(4): 777-780. (AH dl-2 (rev. #2))

Brinks, J. S., Clark, R. T., Kieffer, N. M. and Quesenberry, J. R. 1962. Mature weight in Hereford range cows -- heritability, repeatability, and relationship to calf performance. J. Anim. Sci. 21(3): 501-504. (AH dl-35)

Brown, C. J. and Gacula, Jr., M. C. 1962. Genotype-environment interactions in post-weaning rate of gain of beef cattle. J. Anim. Sci. 21: 924-926. (AH dl-8 (rev.))

Brown, H. E., Kinkel, H. O. and Prescott, J. M. 1963. Fasting amino acid patterns in plasma of normal and dwarf cattle. J. Anim. Sci. 21: 970 (Abstr.) (AH dl-35)

Crockett, J. R., Koger, M. and Chapman, Jr., H. L. 1963. Genetic variations in hemoglobins of beef cattle. J. Anim. Sci. 22: 173-176. (AH dl-34)

Christians, C. J., Chambers, D., Walters, L. E., Whiteman, J. V., and Stephens, D. F. 1962. Heritability estimates of beef characteristics. J. Anim. Sci. 21: 387 (Abstr.) (AH dl-31 (rev.))

Clark, R. T., O'Mary, C. C., Brinks, J. S. and Kieffer, N. M. 1963. Sex ratios in Hereford range cattle. Amer. Soc. Anim. Prod. West. Sect. Proc. 14: VII. (AH dl-2 (rev. #2))

Dinkel, C. A. and Ray, D. E. 1962. Genetic parameters and selection indexes for beef cattle. J. Anim. Sci. 21: 977 (Abstr.) (AH dl-13 (rev. #2))

Gacula, Jr., M. C., and Brown, C. J. 1963. Heritability of performance of beef bulls. J. Anim. Sci. 22(1): 238 (Abstr.) (AH dl-8 (rev.))

Gregory, K. E., Arthaud, V. H., Koch, R. M., and Swiger, L. A. 1962. Inheritance of a spastic lethas in cattle. J. of Heredity 53: 130. (AH dl-12 (rev. #2))

Gregory, K. E., Koch, R. M. and Swiger, L. A. 1962. Malocclusion -- a hereditary defect in cattle. J. of Heredity 53: 168. (AH dl-12 (rev. #2)

Howes, J. R., Feaster, J. P. and Hentges, Jr., J. F. 1962. A comparison of the thyroid release of I-131 by Hereford and Brahman cattle. J. Anim. Sci. 21: 210-213. (AH dl-5 (rev.))

Howes, J. R., Hentges, Jr., J. F., and Davis, G. K. 1963. The comparative digestive powers of Hereford and Brahman cattle. J. Anim. Sci. 22: 22-26. (AH dl-5 (rev.))

Howes, J. R., Hentges, Jr., J. F., and Feaster, J. P. 1963. The blood volume of Brahman and Hereford cattle as measured by radioactive I-131 bovine serum albumen. J. Anim. Sci. 22: 183-187. (AH dl-5 (rev.))

Koch, R. M., Swiger, L. A., Chambers, Doyle, and Gregory, K. E. 1963. Efficiency of feed use in beef cattle. J. Anim. Sci. 22: 486-494. (AH dl-12 (rev. #2))

Marlowe, T. J., Rooney, J. R., and Mestanza, W. F. 1962. A study of dwarfism in beef cattle. Va. Agric. Exp. Sta. Bull. 545. (AH dl-35)

Meyerhoeffer, D. C., Carter, R. C., and Priode, B. M. 1963. Sex differences in heritability of traits in beef calves. J. Anim. Sci. 22: 240. (Abstr.) (AH dl-4 (rev.))

Pahnish, O. F., Roberson, R. L., Taylor, R. L., Brinks, J. S., Clark, R. T., and Roubicek, C. B. 1963. Genetics of growth traits in range cattle. Amer. Soc. Anim. Sci. West. Sect. Proc. 14. (AH dl-14 (rev.))

Reagor, J. C., Omar, E. M., and Kunkel, H. O. 1962. Bovine ruminal development and tolerance to insulin. J. Anim. Sci. 21: 1029 (Abstr.) (AH dl-22 (rev.))

Roberson, Robert L., Pahnish, O. F., Taylor, R. L., Brinks, J. S., Clark, R. T., and Lane, A. M. 1963. Genetics of grade, condition, and weight in range cattle. Amer. Soc. Anim. Sci. West. Sect. Proc. 14. (AH dl-14 (rev.))

Sawyer, W. A., Bogart, Ralph, Wallace, Joe D., Raleigh, R. J., Brinks, J. S., and Clark, R. T. 1963. Relationship among weights of dam and progeny performance. Amer. Soc. Anim. Prod. West. Sect. Proc. 14. (AH dl-19 (rev.))

Shelby, C. E., Harvey, W. R., Clark, R. T., Quesenberry, J. R., and Woodward, R. R. 1963. Estimates of phenotypic and genetic parameters in ten years of Miles City R.O.P. steer data. J. Anim. Sci. 22(2): 346-353. (AH dl-2 (rev. #2))

Stonaker, H. H. 1962. Homogametic heterosis. Amer. Soc. Anim. Prod. West. Sect. Proc. 13: XXIII. (AH dl-16 (rev.))

Stonaker, H. H. 1963. A genetic hypothesis for sex-mating system interactions in growth of cattle and poultry. J. Anim. Sci. 22(2):320-325. (AH dl-16 (rev.))

Taylor, R. L., Pahnish, O. F., Hubbert, Jr., Farris, Hale, W. H. Roberson, R. L., and Brinks, J. S. 1963. Genetics of plasma cholesterol in range cattle. Amer. Soc. Anim. Sci. West. Sect. Proc. 14. (AH dl-14 (rev.))

Tyler, W. S., Julian, L. M., and Gregory, P. W. 1962. Sulphated mucopolysaccharides of urine from brachycephalic dwarfs. Amer. J. Vet. Res. 23 (96): 1109. (AH dl-39)

Performance Testing

Ampy, Franklin, and Bogart, Ralph. 1962. Some physiological studies on growth and feed efficiency in beef cattle (Bos domesticus). Amer. Zool. 2(3): 170. (AH dl-19 (rev.))

Bogart, Ralph, Wallace, Joe D., Raleigh, R. J., Sawyer, W. A., Brinks, J. S., and Clark, R. T. 1963. Effect of level of concentrate feeding on heritability of performance traits in cattle. Amer. Soc. Anim. Prod. West. Sect. Proc. 14. (AH dl-19 (rev.))

Bovard, K. P., Harvey, W. R., and Priode, B. M. 1962. Full vs. shrunk weights for postweaning performance tests. J. Anim. Sci. 21: 969 (Abstr.) (AH dl-4 (rev.))

Bovard, K. P., Priode, B. M. and Harvey, W. R. 1963. Estimates of year, sex, age of dam, age, and inbreeding effects on beef calf performance to weaning. J. Anim. Sci. 22: 244 (Abstr.) (AH dl-4 (rev.))

Cahill, V. R., Kunkel, L. E., Plimpton, Jr., R. F., and Klosterman, E. W. 1961. Edible portion and beef carcass evaluation. J. Anim. Sci. 20: 914 (Abstr.)

Christian, L. L., Ogilvie, M. L., and Hauser, E. R. 1961. Prediction of beef carcass composition and value. J. Anim. Sci. 20: 904 (Abstr.)

Cole, J. W., Ramsey, C. B., and Cavender, A. R. 1962. Effect of weight, grade, and sex of beef carcasses on yield of packaged beef for the freezer. Tenn. Agric. Exp. Sta. Bull. 345. (AH dl-9 (rev.))

Cole, J. W., Ramsey, C. B., and Epley, R. H. 1962. Simplified methods for predicting pounds of lean in beef carcasses. J. Anim. Sci. 21: 355-361. (AH dl-9 (rev.))

Field, R. A., Schoonover, C. O., Nelms, George E., and Kercher, C. J. 1963. Evaluation of some old and new beef carcass measurements. Amer. Soc. Anim. Sci. West. Sect. Proc. 14. (AH dl-25 (rev.))

Flock, D. K., Carter, R. C. and Priode, B. M. 1962. Linear body measurements and other birth observations on beef calves as predictors of preweaning growth rate and weaning type score. J. Anim. Sci. 21: 651-655. (AH dl-4 (rev.))

Gregory, K. E., Swiger, L. A., Arthaud, V. H., Warren, R. B., Hallet, D. K., and Koch, R. M. 1962. Relationships among certain live and carcass characteristics of beef cattle. J. Anim. Sci. 21: 720-727. (AH dl-12 (rev.))

Harwin, G. O., Stonaker, H. H., and Cramer, D. A. 1962. An evaluation of methods for the quantitative estimation of marbling in beef cattle. Amer. Soc. Anim. Prod. West. Sect. Proc. 13: XXXVI. (AH dl-16).

Hoornbeek, F. N., McArthur, J. A. B., Bogart, Ralph, and Kinnick, W. H. 1962. Performance and carcass characteristics in beef cattle. Amer. Soc. Anim. Prod. West. Sect. Proc. 13: XXXII. (AH dl-19 (rev.))

Iwanaga, Isaac I., and Cobb, Estel H. 1963. Relationship between yield of trimmed retail cuts and certain carcass characteristics of beef cattle. Amer. Soc. Anim. Prod. West. Sect. Proc. 14.

Johnston, Jr., W. K., Anglemier, A. F., Bogart, Ralph, and Mack, Marilyn. 1962. Relation of certain blood enzymes to rate of gain in Hereford and Angus cattle. Amer. Soc. Anim. Prod. West. Sect. Proc. 13: III. (AH dl-19 (rev.))

Koger, M., Reynolds, W. L., Meade, J. H., Kirk, W. G., Peacock, F. M., and Kidder, R. W. 1962. Environment, sex, and age of dam effects. J. Anim. Sci. 21: 973. (Abstr.) (AH dl-5 (rev.))

Lehmann, R. P., Legates, J. E., Robison, O. W., Gregory, J. H., and Dillard, E. U. 1962. Preweaning growth patterns in beef calves. J. Anim. Sci. 21: 974 (Abstr.) (AH dl-23 (rev.))

Mahmud, Anuwar, and Cobb, Estel H. 1963. Factors affecting weaning weights, preweaning gains, and conformation scores of beef calves in Hawaii. Amer. Soc. Anim. Prod. West. Sect. Proc. 14.

Marlowe, T. J. 1962. Weights and grades of beef cattle and their relation to performance. Va. Agric. Exp. Sta. Bull. 537. (AH dl-7 (rev.))

Marlowe, T. J. 1962. Relation of mature weight and grade of parent to preweaning performance of beef calves. J. Anim. Sci. 21: 974 (Abstr.) (AH dl-7 (rev.))

Marlowe, T. J. 1963. Effects of condition on grade of beef calves. J. Anim. Sci. 22: 237 (Abstr.) (AH dl-7 (rev.))

Matthews, Doyle J., and Bennett, James A. 1962. Effect of preslaughter rate of gain upon tenderness and other carcass characteristics of beef. J. Anim. Sci. 21(4): 738-743. (AH dl-20 (rev.))

Ramsey, C. B., Cole, J. W., and Hobbs, C. S. 1962. Relation of beef carcass grades, proposed yield grades, and fat thickness to separable lean, fat and bone. J. Anim. Sci. 21: 193-195. (AH dl-9 (rev.))

Rollins, W. C., Carroll, F. D., Pollock, J. W. T. and Kudoda, M. N. 1962. Beef cattle performance and progeny tests for gain, efficiency, carcass conformation and earliness of maturity. J. Anim. Sci. 21: 200-206. (AH dl-40)

Swiger, L. A., Gregory, K. E., Koch, R. M., Rowden, W. W., Arthaud, V. H., and Ingalls, J. E. 1963. Evaluating post-weaning gain of beef calves. J. Anim. Sci. 22: 514-520. (AH dl-12 (rev. #2))

Swiger, L. A., Koch, R. M., Gregory, K. E. and Arthaud, V. H. 1962. Selecting beef cattle for economical gain. J. Anim. Sci. 21: 588-592. (AH dl-12 (rev. #2))

Swiger, L. A., Koch, R. M., Gregory, K. E., Rowden, W. W., and Ingalls, J. E. 1962. Evaluating pre-weaning growth of beef calves. J. Anim. Sci. 21: 781-786. (AH dl-12 (rev. #2))

Thomas, R. C. and Cartwright, T. C. 1962. Factors affecting feedlot gain of Hereford bulls. J. Anim. Sci. 21: 976 (Abstr.) (AH dl-22 (rev.))

Van Arsdel, III, Wm. C., and Bogart, Ralph. 1962. Ambient temperatures, heart rates, rectal temperatures in beef calves. Amer. Soc. Anim. Prod. West. Sect. Proc. 13: II. (AH dl-19 (rev.))

Wagnon, Kenneth A., and Rollins, W. C. 1962. Factors affecting fill and consequently overnight shrinkage in range cattle. J. Range Management 15: 158-161. (AH dl-39)

Wallace, Joe D., Raleigh, R. J., Bogart, Ralph, Sawyer, W. A., Brinks, J. S., and Clark, R. T. 1963. Relationship among performance traits in young cattle as influenced by nutritional level. Amer. Soc. Anim. Prod. West. Sect. Proc. 14. (AH dl-19 (rev.))

Selection and Systems of Breeding

Bovard, K. P., and Priode, B. M. 1962. Conception rates in beef cows as affected by inbreeding of fetus, and by age and inbreeding of cows. Va. Jour. of Sci. n.s., 13: 210. (AH dl-4 (rev.))

Brinks, J. S., Clark, R. T., and Kieffer, N. M. 1963. Sex differences in response to inbreeding in a line of Hereford cattle. Amer. Soc. Anim. Prod. West. Sect. Proc. 14: V-1-6. (AH dl-2 (rev. #2))

Butler, O. D., Cartwright, T. C., Kunkle, L. E., Orts, F. A., King, G. T., and Lewter, D. W. 1962. Comparative feedlot performance and carcass characteristics of Hereford and Angus steers. J. Anim. Sci. 21: 298-301. (AH dl-22 (rev.))

Cunha, T. J., Koger, M. and Warnick, A. C. 1963. Crossbreeding beef cattle. Univ. of Florida Press, Gainesville. (AH dl-5 (rev.))

Koger, Marvin. 1963. Selection for maternal ability in beef cattle. J. Anim. Sci. 22: 245 (Abstr.) (AH dl-5 (rev.))

Koger, M., Hargrove, D. D., Peacock, F. M., Cunha, T. J., and Palmer, A. Z. 1962. Feed conversion in straightbred and crossbred calves. J. Anim. Sci. 21: 973 (Abstr.) (AH dl-5 (rev.))

Willson, F. S., Flower, A. E., Kieffer, N. M., and Miller, R. W. 1963. Topcross tests of R.O.P. and visually selected herds of Hereford cattle. Amer. Soc. Anim. Prod. West. Sect. Proc. 14. (AH dl-1 (rev. #2))

AREA NO. 3: BEEF CATTLE -- PHYSIOLOGY

Problem. In the average lifetime of a beef cow, under optimum conditions, she will wean only 5 or 6 calves. Under suboptimum conditions, she may wean as few as 3 or 4 calves. In most cases the calving season will last at least 3 or 4 months and calving for 12 months or on a year-round basis is not uncommon. Cows or heifers not showing heat during the early part of the breeding season and a low conception rate at first service are two of the major causes of low reproductive performance. Methods must be found to improve reproductive efficiency so that the number of calves weaned per cow will be higher and cows will calve over a relatively short period of time, thus yielding more pounds of calf. Also, more information concerning physiological processes involved in feed conversion could lead to more efficient animals. Furthermore, data on effect of climatic conditions on physiological response of cattle are needed. These data could be utilized to provide information so management practices could be altered to increase production.

USDA PROGRAM

The program at the present time is mainly concerned with methods of improving, controlling or altering reproductive performance by hormonal, nutritional or other methods. It is carried on by physiologists and animal husbandmen at Beltsville, Maryland, and at the Department's Fort Robinson, Nebraska; Miles City, Montana; Jeanerette, Louisiana, and Fort Reno, Oklahoma, stations in cooperation with the respective State Experiment Stations. Studies on the causes of reproductive failures are conducted with the herds at all these locations. Investigations on the relationship between reproductive performance and protein and energy intake levels are in progress at Beltsville, Fort Robinson, Jeanerette and Miles City. Also at Beltsville, studies are in progress on the reproductive performance of cattle exposed to high temperatures and humidity. Studies are underway at Miles City and Fort Robinson to determine the relationship between anatomy of the pelvis and calving difficulties. Other studies at Fort Robinson include work on control of the estrous cycle and the effect of low doses of estrogenic hormones on ovarian activity.

The Federal scientific effort devoted to research in this area totals 3.5 professional man-years of which 3.1 are devoted to physiology of reproduction and .4 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Nutrition and reproduction. Effect of protein and energy on reproduction is being studied at the Agricultural Research Center, Beltsville, Maryland. Fifty-eight grade Angus heifers, weighing an average of 420 pounds, were allotted to six treatments ranging from a full-feed (approximately 18 pounds) to 4.6 pounds of feed daily. After 59 weeks on experiment the heifers vary in body weight from an average of 960 pounds for the heifers fed ad lib. to 470 pounds for the heifers fed the lowest level. All animals have shown estrus with the exception of three heifers in the two groups receiving the lowest level of nutrition; also six heifers in these groups ceased cycling after showing estrus. These heifers were raised to a higher level of nutrition to bring them back into heat. One hundred percent of the heifers have been bred in the four higher level groups while 90 and 28 percent of the heifers on the two lower levels of nutrition have been bred. The conception rate for all heifers regardless of nutritional level has been normal. Total serum protein, which is determined every six months, appears to decrease with time in all groups except in the heifers in the ad lib. group. (AH d2-22)

The effect of four levels of winter feeding and two levels of summer grazing on reproductive performance of Hereford heifers bred to calve at two years of age was studied at Fort Reno Experiment Station in El Reno, Oklahoma. All heifers on high or moderate levels of winter feeding showed heat during breeding season. Seven of the 15 heifers on low levels of winter feeding and restricted summer grazing did not show heat during breeding season. Heifers on higher levels of winter feeding tended to reach puberty sooner. If first heat was exhibited during winter months, regular estrous cycles tended to be established in most of the heifers on high and moderate levels of winter feed but in very few of the heifers on low levels of feed. Most of the heifers (93 or 100%) on high or moderate levels of winter feed or on low winter feed and high levels of early spring feed became pregnant during the breeding season. In heifers on low levels of winter feed and continuous summer grazing, 73% became pregnant while 53% of those on low levels of winter feed and restricted summer grazing were diagnosed pregnant. Conception of heifers conceiving on low levels of winter feed occurred later in the breeding season. These results show that low levels of winter feed delay the onset of sexual maturity. This delay leads to unsatisfactory reproductive performance especially when it is associated with low levels of summer grazing. (AH d2-12)

Work at the Iberia Livestock Station at Jeanerette, Louisiana, indicates low reproductive performance in young lactating cows is the result of insufficient nutrients being supplied by pasture during winter and early spring months. The percent of lactating two-year-old heifers becoming pregnant in a 100-day breeding period was Group 1 (pasture only) 54%; Group 2 (drylot weight gains equivalent to pasture only) 46%; Group 3 (fed NRC recommenda-

tions in drylot) 85%; Group 4 (pasture plus supplement to give weight gains equivalent to weight gains of Group 3) 82%.

The major cause of reproductive failure was a delay in the onset of heat following calving. Fifteen percent of the cows in Group 1 and 8% of the cows in Group 2 did not show heat during the breeding period. In addition, the percentage of cows showing heat by the 43rd day of the breeding season was 15%, 8%, 62%, and 64% for Group 1 through 4, respectively. The interval from calving to first heat for cows showing heat prior to the end of the breeding season was 122, 141, 113, and 100 days, respectively, for Group 1 through 4. The proportion of the lactating heifers conceiving at first service was 45% and 36% for Groups 1 and 2 compared to 62% and 73% of cows settled at the first service; Groups 3 and 4. Feed provided to animals in Group 2 (drylot) to equal gains of the pasture only (Group 1) varied from a TDN of 4.5 in January and February to 16.8 pounds in April and May. Heifers, therefore, appeared to obtain insufficient energy in the winter and early spring months to support optimum reproduction. (AH d2-34)

An experiment is being conducted at Fort Robinson, Nebraska, to determine the effect of different levels of energy before and after calving on reproductive performance of heifers calving at 2 years of age. Two hundred and forty Angus and Hereford heifers are being used. Before calving a high level (8.3 lbs. of TDN) and a low level (4.1 lbs. of TDN) of energy are being fed. The high group before calving is divided into three groups after calving; full-fed (approximately 19.0 lbs. of TDN) and a high group (13.0 lbs. of TDN).

Cows are placed on experimental rations 140 days before calving. Marked differences in body weights and body condition have been noted. Cows on low levels of feed prior to calving lost approximately 40 lbs. and 2 condition scores while cows on high levels of feed gained 120 lbs. and condition remained constant. Data on reproductive performance are not yet available. (AH d1-37)

A study of the effects of energy level on growth and reproduction of range heifers is being conducted at the Range Experiment Station at Miles City, Montana. The study involves 48 Hereford heifers grazed on range throughout the trial with supplemental feeding divided into two phases. During the 140-day wintering phase the heifers were individually fed, every-other day, either two pounds of a 40% protein pellet or 4 pounds of a 20% protein pellet. Rations were formulated to provide equivalent amounts of protein, vitamin A and phosphorus but differing in energy content. The second feeding phase consists of a 56-day prebreeding feed period in which both wintering ration groups were divided into groups receiving either range only or four pounds of the 20 percent protein pellet fed individually every other day, thus giving four final nutritional regimes, LL, LH, HL, and HH.

Results to date have not indicated marked differences in body growth measurements or weight gains. Reproductive tract growth has been similar among ration groups but there is some evidence that estrual activity is greater in

heifers receiving higher levels of energy during the prebreeding period. Number of heifers in heat are 3, 4, 1, and 5 for LL, LH, HL, and HH, respectively.

All heifers will be exposed to a fertile bull for a 60-day breeding season and the number of heifers bred and conception rates will be studied. (AH d1-33)

2. Control of estrus. Attempts have been made to synchronize estrous cycles at Fort Robinson, Nebraska. Eighty cycling heifers received 18 daily injections of various combinations of progesterones and estradiol (20 mg. progesterone with 80 mcg. and 160 mcg. of estradiol and 40 mg. progesterone with 80 mcg and 160 mcg. estradiol). The percent synchronized over a four-day period was 95 and 100% for the two groups. The conception rate at the synchronized estrus ranged from 20% to 32% compared to 58% for a control group.

Forty cycling heifers were individually fed oral progesterone (droxone from E. R. Squibb and Co.) twice each day. The four dosage levels were 4 grams, 2 grams, 1 gram, and 1/2 gram. The proportions showing estrus in a four-day period following termination of treatment were 100, 70, 90, and 80 for the 1/2 gram, 1 gram, 2 grams, and 4 grams, respectively. The proportion pregnant varied from 10 to 22%.

Ninety heifers were given a single injection of a long acting progesterone (droxone) or a combination of a long acting progesterone with a long acting estrogen (estradiol enanthate). The levels used were: 62.5 mg. of droxone with 0; 0.125 mcg. or 0.25 mcg. estradiol enanthate; 125 mg. of droxone with 0; .25 mcg. or 0.5 mcg. estradiol enanthate; 250 mg. droxone with 0; 0.5 mcg. or 1.0 mcg. estradiol enanthate. Poor synchronization was obtained with 40 to 50% of the heifers showing estrus in a four-day period. Fertility ranged from 0 to 33%.

Results from these trials indicate that good synchronization can be obtained by feeding or daily injections. However, fertility at the synchronized heat is poor. (AH d1-37)

A study to determine causes of maintenance and regression of corpus luteum has been conducted at Fort Robinson. Ninety-nine yearling Hereford heifers were assigned to a cycling, pregnant or hysterectomized group to study the effects of various estrogens on ovarian activity. Single intramuscular injections of either 50 mg. estradiol - 17 beta; 50 mg. estradiol - 17 alpha; 50 mg. estrone; or 5 mg. estradiol valerate were administered on day 5 in the cycling and hysterectomized heifers and on day 35 in the pregnant heifers. Heifers were laparotomized or hysterectomized and corpora lutea marked with India ink at the time of hormone treatment. Ovariectomies were performed 7 days after the hormone treatment. Estrogen treatment significantly reduced corpus luteum weight, progesterone concentration, progesterone content and ovarian follicular fluid weight in all three reproductive groups. Average

values for the cycling, pregnant and hysterectomized control groups were: 3.06, 3.03 and 3.32 gm. for corpus luteum weight; 17.9, 15.9 and 28.6 mcg./gm. for progesterone concentration; 55.1, 47.4 and 93.7 mcg. for progesterone content; and 4.32, 3.36 and 2.94 for follicular fluid weight, respectively. Average values for the treated groups ranged from 1.88 to 2.53 gm. for corpus luteum weight; 7.5 to 18.4 mcg./gm. for progesterone concentration; 15.1 to 45.4 mcg. for progesterone content; and 2.17 to 2.77 for follicular fluid weight. Estradiol - 17 beta was the most effective estrogen while estradiol - 17 alpha was the least effective. Heifers of different reproductive states (cycling, pregnant and hysterectomized) responded similarly to the different forms of estrogen administered for all of the indices of ovarian function studied (reproductive state x hormone treatment interactions; small and non-significant). Thus, no evidence was obtained to support the hypothesis that the uterus affects ovarian function by metabolic utilization or transformation of estrogens. (AH d1-37)

3. Temperature effects on reproduction. At Beltsville, in December, 1962, six Hereford heifers were placed in a psychrometric chamber at 90°F. and 60% relative humidity. All heifers stopped having estrual cycles after being subjected to the heat stress. After seven weeks, two heifers had to be removed from the chamber because of nerve damage to the rear legs. Body temperatures and water consumption rose to high peaks by the fifth week and at this time declined along with the shedding of the hair coat. These reactions were similar to the other trials indicating adaptation is important in their response to heat stress and the resulting effect on the estrous cycle. Three of the four remaining heifers reestablished their estrous cycles after 16 weeks exposure to heat stress and have been bred. (AH d1-30)

4. Losses at or near calving. In efforts to ascertain causes of stillbirths the area of the dam's pelvic opening is being determined in all first calf heifers at Miles City. In addition to internal pelvic measurements, external measurements in terms of hip width and rump length are also being determined. These measurements will be correlated with each other and with severity of calving difficulty. To date, age differences within breeds have been noted as shown by comparing Hereford two and three-year-olds, respectively, as to: area of pelvic opening, 228.3 vs. 289.9 sq. cm.; hip width, 17.2 vs. 20.4 inches; and rump length, 17.3 vs. 19.6 inches. Breed differences within age groups are also apparent as shown by comparing three-year-old Herefords with three-year-old Charolaise, respectively: area of pelvic opening, 289.9 vs. 328.0 sq. cm.; hip width, 20.4 vs. 21.6 inches; rump length 19.6 vs. 20.7 inches.

Calves from first calf heifers are being measured within 24 hours following birth to determine width of head, shoulders and hips and depth of chest. These measurements will be used to study breed differences in calf size and to estimate what might be considered a "minimum" pelvic opening. (AH d1-33)

5. Reproductive phenomena. In a study of reproductive rates in the southern region over a four-year period, several things of an "environmental" nature were shown to be related to fertility. They would have to be taken into account in comparing fertility of individuals or sire progeny groups.

On the average, cows that were nursing a calf when bred weaned approximately four percent more calves during the subsequent season than did cows which were dry when bred. Four-year-old cows, when bred, weaned four and one-half percent more calves than the average. Yearlings were approximately one percent below the average, two-year-olds were two percent below, and three-year-olds were approximately one percent below. In this four year study, pasture mating of cows resulted in approximately 36 percent more calves than did artificial insemination. There was little difference in percent of conception between hand mating and pasture mating. It is interesting to note that approximately eight percent of the cows in this study were removed each year for reproductive causes.

In one study on cows that did not conceive during the regular breeding season, it was noted that during a subsequent 27-day breeding period, cows nursing calves had a lower pregnancy percent (43%) than cows not nursing calves (62%). It was also noted that supplemental feeding further increased the conception rate of these cows. A study was conducted at the same station on the relationship between the growth rate of heifers up to two years of age and their subsequent calving percent at three years of age. In general, lightweight calves at weaning had lower subsequent fertility rates than heavier calves. (AH d1-6, d1-30)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Physiology of Reproduction

Kaltenbach, C. C. and Wiltbank, J. N. 1962. Heterotic effects of age and weight at puberty in beef heifers. Am. Soc. of An. Prod. West. Sect. Proc. 13, p. XXIV. (AH d1-37)

Kaltenbach, C. C. 1963. Alteration of ovarian activity in cycling, pregnant and hysterectomized heifers with exogenous estrogens. M.S. Thesis, University of Nebraska Library. (AH d1-37)

Reynolds, W. L. 1963. The age and weight at puberty of Angus, Brahman and Zebu cross heifers. J. Anim. Sci. 22: 243 (Abstr.) (AH d1-30 (rev.))

Turman, E. J., Pope, L. S., Watkins, B. J., Pinney, D. O., McNutt, D. D., and Stephens, D. F. 1963. The reproductive performance of Hereford heifers on different levels of winter feeding and summer grazing. Okla. Agric. Exp. Sta. Misc. Pub. 70. (AH d2-12)

Wiltbank, J. N., Rowden, W. W., Ingalls, J. E., and Zimmerman, D. R. 1962. Influence of post-partum energy intake on reproductive performance of Hereford cows restricted in energy intake prior to calving. Am. Soc. of An. Prod. West. Sect. Proc., 13: X. (AH d1-37)

Wiltbank, J. N. and Zimmerman, D. R. 1962. Estrus synchronization and fertility in Hereford heifers subsequent to administration of progesterone and estradiol. Am. Soc. of An. Prod. West. Sect. Proc. 13: XVII. (AH d1-37)

AREA NO. 4: BEEF CATTLE -- NUTRITION AND MANAGEMENT

Problem. Producers of beef cattle need improved feeding methods which will result in optimum pasture gains, reduced feed consumption per pound of beef produced, optimum reproductive rates and desired carcass qualities. To meet these needs basic nutritional information is required such as: When should beef animals be fed for maximum gains and when for more limited gains? What nutrient combinations produce rapid growth of muscle with a minimum of fat deposition? How may breeding animals be economically raised that will be capable of a high level of reproductive performance over a long lifetime? What are the nutritive contributions made by range and pasture and what supplementation is required when they are used? Research is also needed on the relation between animal production and types of shelters and equipment, feeding systems, and methods of increasing labor efficiency.

USDA PROGRAM

This is a continuing program carried on by nutritionists, biochemists and animal husbandmen on basic and applied problems related to feeding and management of cattle for beef. The work is in progress at Beltsville, Maryland; in cooperation with State Experiment Stations at federally owned stations in Miles City, Mont.; Fort Robinson, Nebr.; Fort Reno, Okla.; Jeanerette, La.; Brooksville, Fla.; and Front Royal, Va.; and in cooperation with State Experiment Stations at Raleigh, N. C.; Tifton, Ga.; College Station, Tex.; and Newell, S. Dak.

The Federal scientific effort devoted to research in this area totals 10.3 professional man years. Of this number 2.7 are devoted to digestion and metabolism; .6 to concentrates; 2.7 to forage preservation and utilization; 1.4 to nutrient requirements; 1.0 to range and pasture management; .7 to management practices; and 1.2 to program leadership.

There is one grant involving Public Law 480 funds with the Agricultural College in Poznan, Poland. The project is on content of trace minerals in forage crops in relation to the stage of development of the plants and the method of gathering and storing. It is supported for five years (1963 to 1968) by $47,311.66 equivalent in Polish zlotys.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

1. Digestion techniques. Data collected since 1957 on application of the chromic oxide technique for estimating digestibility of complete, mixed, and pelleted rations have been summarized. Small but significant differences between total collection and indicator techniques for esti-

mating digestibilities were observed. Variances calculated for daily digestion coefficients were greater for values determined by the total collection procedure than by the Cr_2O_3 techniques. Incorporating Cr_2O_3 in a pelleted, complete ration and taking fecal grab samples at 9 a.m. and 3 p.m. for 5 days are considered to be a satisfactory technique for estimating dry matter digestibilities with steers.

At North Carolina, work has continued on the relation of chemical composition to digestibility. The research indicates if one could determine "nutritive entities" of feed, the chemical composition (%) of the entity would be linearly related to the digestible amount of that entity, the slope of the line would be the digestion coefficient and the intercept would be the metabolic amount of that entity. Five different feeds have been used in digestion trials and the results show that crude protein except for lespedeza fits the theory quite well; so do ether extract, ash, water-soluble carbohydrates, and 4% H_2SO_4-hydrolysable carbohydrates. The main problem still remains in the complex carbohydrate fraction.

Work has continued on the determination of the properties of the enzyme inhibitor which is present in sericea lespedeza. Its molecular weight is apparently between 10,000 and 15,000. In vitro it is inhibitory to cellulases, pectinases, pectin-esterase, amylases, and proteinase.

Identical twin heifers are being used to determine if the feeding of a purified diet, which contains urea as the only nitrogen source, will alter growth and reproductive performance. One heifer of each set is being fed a natural ration which contains 75% concentrates while the remaining heifer is being fed a purified ration of the following composition in percentage: corn starch, 28.6; corn sugar, 28.6; cellulose, 30.0; urea, 4.2; soybean oil, 2.0; mineral mix, 6.5; choline chloride, 0.1; and vitamins A and D. These rations are being fed on an isocaloric and isonitrogenous basis. The heifers were started on the rations weighing about 275 lb. each and after 196 days on experiment the heifers on the purified diet gained 0.80 lb. daily while those on the natural ration gained 1.20 lb. daily. Skeletal measurements after 180 days on ration indicated that the heifers on the purified rations were increasing in skeletal size slightly faster than the other heifers. After the heifers obtain a weight of approximately 600 lb. they will be bred and further data will be obtained during gestation and after calving while still consuming the same rations. (AH d2-8, d2-14)

2. Pasture bloat in beef cattle. Research on factors contributing to pasture bloat at Beltsville and at Mississippi State College has been continued. Ethanol precipitated slime fractions have been isolated from centrifuged ruminal fluid of steers bloating on clover pastures. The amount of slime increased during grazing when the animals bloated. Analysis showed the fractions contained 61 to 64% protein, 8 to 14% carbohydrate and 7 to 10% ribonucleic acid. The slime fraction contained 17 amino acids, the sugars d-ribose, arabinose, and glucose and the purines and pyrimidines

adenine, guanine, cytosine, and uracil. Clover cytoplasmic protein has been implicated as a major source of stable foam in pasture bloat. In feedlot bloat, increases in dry weight of the ethanol insoluble material have been related to the onset and severity of bloat. The ethanol-insoluble fraction in clover bloaters showed approximately the same range of increases before and after bloat as did animals bloating on grain. The slime fraction of the legume bloaters and of the feedlot bloat animals was similar in having a protein, carbohydrate and nucleic acid composition but differs in the kind of nucleic acid component. In the grain bloater the nucleic acid is of the DNA type while in the legume bloaters the nucleic acid in the slime fraction is of the RNA type. The occurrence of protein, carbohydrate, and nucleic acid in the slime fractions of both the grain and legume bloaters, and the increase of the slime with the onset of symptoms suggest these compounds may contribute to the development of bloat. (AH d2-13)

3. Urinary calculi. Basic and applied studies into the cause and prevention of urinary calculi were conducted with both steers and wethers at College Station and Big Spring, Texas, and with steers at Fort Reno, Oklahoma.

The steer studies at College Station were part of a feeding trial comparing rations of ground moist sorghum grain or ground moist sorghum heads with and without Coastal Bermuda haylage. While there were no clinical cases of calculi, 43 of the 50 steers in this test did have stones in the bladder at the time of slaughter.

In all treatments, the number of animals with stones was much too high. Insofar as quantity is concerned, there was no significant difference among the treatments using haylage, but there were significantly greater numbers of stones in steers not fed haylage than in steers fed haylage.

The Fort Reno work was part of a study concerned with the utilization of sorghum grain as related to the method of feeding and the data were developed from sire groups and cross treatments. Five of the 74 steers used in this test developed clinical cases of urolithiasis and 26 more had stones in the bladder at the time of slaughter. Three of the five clinical cases were in one sire group while the fourth case was sired by a half brother. Ten of the 16 steers by these two bulls developed stones and the offspring of these two bulls accounted for 80% of the clinical cases and 30% of all the steers affected. While the numbers are small, it does indicate the possibility of certain blood lines being susceptible to calculi formation. The combined steer and wether experiments at Big Spring made up the second year of a three-year test attempting to resolve or confirm the apparent difference in response of the steer and the wether to factors involved in calculi formation. There were no clinical cases of calculi in the steers. However, all of the steers fed the basal ration and the basal ration plus 1% disodium phosphate had stones in the bladder. The addition of 1% Carbotex (a commercial ground limestone product) resulted in a 37% decrease in the number of steers having stones in the bladder while the addition of 1.5 oz. per head daily of ammonium chloride reduced the incidence by 63%.

In contrast, wethers receiving a ration prepared from the same ingredients used in the steer ration had only one animal in the basal ration treatment group develop stones. Nine clinical cases of calculi developed during the test. Eight of the lambs receiving disodium phosphate and one from the Carbotex group developed stones. None of the lambs receiving ammonium chloride had stones in the bladder at the time of slaughter. While definite conclusions are being withheld pending the completion of all three years of the study, it would appear that different dietary mineral ratios or mechanisms may be involved in calculi formation in the steer than in the wether, but ammonium chloride seems to offer an effective means of the control of urolithiasis for both the steer and the wether. The addition of disodium phosphate to the wether ration definitely increased the calculogenecity as shown by a 5% incidence for the control or basal ration and a 65% incidence when the disodium phosphate was added.

The studies at College Station with wether lambs were designed to test the effect of pelleting, the size of the pellet, and the addition of sodium or potassium chloride to the ration. The results of pelleting were slightly different than observed in previous work. Calculogenecity was increased when the ration was pelleted which corresponded to previous observations. However, the greatest increase was found in the 3/8 in. pellet instead of the 1/4 in. pellet. Also the lambs fed the 1/4 in. pellet gained essentially the same as the lambs fed the 3/8 in. pellet and at about the same feed efficiency. Combining the two year's work insofar as calculogenecity is concerned, 38% of the lambs fed the basal ration developed stones while 54 and 58% of lambs receiving 3/8 and 1/4 in. pellets, respectively, developed stones.

The addition of 1% chloride to the basal ration decreased the incidence from 38 to 25%. Sixty percent of the lambs affected were clinical cases. When 1% potassium chloride was used in the place of sodium chloride, the incidence was reduced to 10% with no clinical cases. These results tend to refute the efficiency of sodium chloride in the control of calculi. Since previous work has indicated that potassium tends to prevent calculi in wethers, potassium chloride could have been expected to offer a measure of protection.

Variations in the dietary mineral intakes of steers were studied at Beltsville to determine if diets which produce a high incidence of urinary calculi in fattening lambs were equally calculogenic when fed to steers. Steers were fed diets of known mineral composition which contained an excess of phosphorus (.75%) in the presence of high and low calcium (.025 and 1.50%) and high and low potassium (0.35 and 2.00%). These diets were not predisposing to urolithiasis when fed for a 98-day feeding period. Metabolism data including the amount of minerals in the feces and urine and the serum mineral levels are being studied to determine to what extent the mineral metabolism of these animals was affected.

Two studies were made with laboratory rats to investigate the effects of dietary mineral imbalances on the development of urinary calculi. The vari-

ables, expressed as a percent of the synthetic diet, were two levels of calcium, 1.2 and 0.3; two levels of phosphorus, 1.2 and 0.3; three levels of magnesium, 0.5, 0.25, and 0.05; and two levels of potassium, 0.9 and 0.1. Urinary calculi occurred in four of six animals which received the diet that contained .3% calcium, 1.2% phosphorus, .5% magnesium, and .1% potassium. None of the other 23 diets were calculogenic to the animals which were fed for 14 weeks. Certain dietary mineral imbalances appear to give rise to conditions which promote the development of urinary calculi. (AH d2-31)

4. Pesticide residues. In vitro experiments with organophosphate, chlorinated hydrocarbon, and carbamate containing insecticides were tested with bovine rumen ingesta fractions. The main experimental approaches have been (1) bacterial growth responses to the insecticides in incubated rumen fluid, (2) bacterial studies for the detection of bacterial breakdown of the insecticides, (3) manometric studies using washed suspensions of ruminal ciliates, bacteria, and plant debris with insecticides, (4) determination of quantities of volatile fatty acids produced by the ruminal ciliates incubated with insecticides, and (5) the use of radioisotope and colorimetric techniques for the measurement of insecticide uptake by the ruminal ciliates.

Ruminal bacteria exposed to 0 to 500 ppm. insecticide levels in rumen fluid starch feed extract medium. No apparent significant bacterial population inhibitions were noted with Dimethoate, Diazinon, lindane, Thiodan, Sevin, and Guthion. Warburg manometric experiments showed paraffin oil-Triton X-155 preparations of Dimethoate, Diazinon, lindane, Thiodan, and Sevin stimulated gas production in holotrich protozoa. Entodinium simplex, and oligotrich, produced less gas with Diazinon substrate than did Isotricha sp. Thiodan breakdown experiments with Isotricha were followed colorimetrically and a 15% loss in substrate occurred during short incubation periods. Diazinon-C-14 uptake by E. simplex and I. intestinalis was measured and significant increases in counts were found in the protozoan cells. Ruminal protozoa are useful as bio-assay tools for screening insecticides which are susceptible to microbial breakdown and may be used on forage and other cattle feed crops.

Studies with pesticides that may be ingested by ruminants were conducted by using both in vivo and in vitro methods. Residue studies were continued to determine specific information as to the effects of Thiodan ingestion by beef cattle. Steers were fed Thiodan by mixing the pesticide with the diet. Steers were confined to metabolism stalls for urine and fecal collections. Tissue residues of 0.5 and 1.0 ppm. of Thiodan were found in omental fat samples of steers receiving 1.10 mg. of Thiodan per kg. of body weight for 30 and 60 days, respectively. At this level of Thiodan intake, the amount of the pesticide occurring in the feces and urine was 6.2% of the total daily intake. The low levels of Thiodan found in the omental fat and excreted in the feces and urine indicate that this compound is probably metabolized. Further analyses of tissues in which a residue of Thiodan was found by the colorimetric method are being made by the use of gas chromatography. This method of analysis will provide a technique to determine if possible metabolic products if the pesticides are present. (AH d2-32)

5. Microbiology of the rumen. Research on various phases of the physiology of the ruminal protozoa have been continued. Besides participating in the breakdown of protein and carbohydrate, several species of the protozoa have been shown to contribute to the lipid metabolism of the rumen. Washed suspensions of the ruminal ciliates I. prostoma and E. simplex concentrated C-14 fatty acids such as oleic, stearic and palmitic. Radioautographs demonstrated that oleic acid was hydrogenated to stearic acid by I. prostoma, and Warburg manometric data showed the sodium salts of oleic, valeric and caproic stimulated acid fermentation by I. prostoma. The total lipid and free fatty acid contents of I. prostoma were determined. Volatile fatty acids were produced by I. intestinalis and ruminal bacteria with tributyrin, but not with tripalmitin. Comparison of mixtures of ruminal bacteria from calves harboring either I. intestinalis or E. simplex indicated they were similar in their response to fatty acids when measured manometrically.

Preliminary results with silicic acid columns and organic solvents indicate that approximately 40% of this lipid is a carbohydrate containing phospholipid. Sterol components are present in the Isotricha lipid both in the sterol and the diglyceride (free sterol) fractions. Other preliminary data indicate that Isotricha sp. respond to sterols dissolved in paraffin oil, particularly corticosterone. Hexestrol stimulates less gas production with Isotricha sp. than with corticosterone. Entodinium simplex is stimulated by either corticosterone or androstendione. (AH d2-24, d2-26)

6. Value of high-nitrogen molasses. In metabolism studies in which 40% of the ration was either a hi-N-molasses, molasses plus urea, or molasses plus cottonseed meal, the dry matter and energy were less digestible in the hi-N-molasses ration than in the rations containing urea. Fiber digestibility was less in the hi-N-molasses ration than in the cottonseed meal-molasses ration and crude protein was more digestible in the urea containing rations than in those rations containing no urea.

Results from both metabolism trials indicated there were no ration differences related to nitrogen retention where expressed as grams per day or as a percent of the nitrogen consumed. (AH d2-14)

7. Coumestrol feeding. Preliminary studies with the feeding of 0, 1, and 5 gm. of coumestrol to growing steers resulted in a decrease in the apparent digestibility of crude protein by animals consuming coumestrol and an increase in the percentage of nitrogen retained. Average daily gains appeared to be linearly related to coumestrol intake, but when expressed on a shrunk weight basis, there appeared to be no difference. The blood serum albumin to globulin ratio was slightly less for the coumestrol fed animals. (AH d2-8)

8. Anatomical and physiological factors affecting digestibility. Fiber utilization by calves being fed fiber per os and via abomasal fistulae is being studied.

Initial studies to determine some of the ruminal factors which influence the rate of salivary secretion have been completed. Large between animal variations were apparent as was a 30 to 40 min. adaptation period during collection of the saliva from the esophageal cannulae. Studies are now in progress with four steers having ruminal and esophageal fistulae (AH d2-8)

B. Concentrates

1. High-concentrate rations for finishing steers. A series of trials using high-concentrate rations for finishing cattle have been completed at Beltsville, Maryland. The basal rations contained ground shelled corn or ground corn and cob meal, soybean meal, salt, steamed bone meal, and vitamin A. These rations were supplemented by high levels of vitamin A and steamed bone meal, urea, mineral buffers, and zinc used alone or in various combinations. The effect of different levels of crude fiber in the rations and the effect of pelleting these rations were determined.

It was found that cattle consumed significantly more corn and cob ration (7.0% crude fiber) than cattle receiving a ground shelled corn ration (3.0% crude fiber); however, the daily gains, feed efficiency, and carcass data were not significantly different. From these data there appears to be no benefit from increasing the crude fiber in the ration by use of corn cobs. The addition of 2,500 U.S.P. units of supplemental vitamin A per pound of ration did not statistically affect the feedlot or carcass data of cattle when compared to cattle receiving 500 U.S.P. units. The lower level seemed adequate in these rations, but there was a slight trend for the cattle to gain faster during the summer months on the high supplemental level. This was not apparent during the winter months. Analysis of liver samples indicated significantly greater storage of vitamin A of cattle consuming greater storage of vitamin A of cattle consuming greater amounts of the vitamin. There appeared to be no benefit from 2 or 5% steamed bone meal over the 1% steamed bone meal present in the basal ration.

A trial was designed to determine the effects of mineral buffers (2.1% potassium carbonate, 2.0% calcium carbonate, and 0.5% magnesium sulphate vs. none) protein sources (urea vs. soybean meal) and zinc level (25 ppm. vs. 125 ppm.) on the performance of cattle consuming a high concentrate ration based around shelled corn. Results indicated no statistically significant differences in gains among groups of cattle. However, there was a trend for lowered gains among groups of cattle consuming the buffered rations. It was found that cattle consuming the rations containing added mineral buffers had significantly lowered carcass grades and less fat over the rib eye than cattle receiving the non-buffered rations. Considerable bloat was encountered by cattle consuming the buffered rations while there was very little in the groups of cattle receiving non-buffered rations.

In a trial at Tifton, Georgia, to determine the value of hay and a complex supplement in high concentrate rations based on snapped corn, steers fed the supplement and ground snapped corn with or without hay had slightly higher

feed consumption, rate of gain, and carcass grade than steers fed the standard ration. The addition of vitamin A to the standard ration appeared to improve slightly feed consumption, gain, and carcass grade. (AH d2-14)

C. Forage Preservation and Utilization

1. Utilization of Coastal Bermudagrass. In a 75-day drylot feeding trial at Tifton, Georgia, steer calves were full fed Coastal Bermudagrass hay, good quality Pensacola Bahia grass hay, and poor quality Pensacola Bahia grass hay. The good quality Bahia hay was cut just after the emergence of seed heads and the poor quality cut just after harvest of the seed crop. The results show that the steers fed the good quality Bahia gained approximately twice as fast as the other groups. The daily Bahia hay consumption was about 20% greater.

Cows wintered on a full feed of Coastal Bermudagrass hay were compared with cows grazing on pasture for 4 or 5 hours per day plus a limited amount of Coastal Bermudagrass hay. The birth weights of calves dropped by the grazing cows were about 7 lb. heavier and the calves gained about 20% faster than those of cows fed hay. The cost of wintering per cow or per day was essentially the same for both treatments. (AH d2-3)

In studies at North Carolina, 64 yearling steers were used to determine the influence of energy and protein supplements on performance and carcass value of cattle grazing nitrated Coastal Bermudagrass. There appeared to be no benefit from adding protein supplement over and above the energy derived from the supplement. Self feeding corn-fat mixtures appeared to have considerable value as a method of enhancing the growth-fattening process of steers being finished on Coastal Bermuda pastures. (AH d2-8)

2. Feeding value of pelleted feeds. At Beltsville physical state-animal behavior studies have indicated that the rate or spread of feed consumption is directly related to body weight of the animal and that the type of ration offered may affect that relationship. This is, the slope of the regression line of rate upon weight for the pelleted high roughage ration was greater than the slope for the same ration when fed as a coarsely ground mixture.

Facilities are now being prepared for studying the effect of light and competition upon the feeding behavior of drylot fed steers.

The feeding value of pelleted feed is being studied at several locations. At Tifton, Georgia, high quality Coastal Bermudagrass pellets were supplemented with a complex mixture which contained protein, molasses, minerals, and vitamin A. In 140-day feeding trial, performance of steers fed a high quality Coastal Bermudagrass pellet was not appreciably affected by replacing 10% of the pellets with the complex supplement. There was a slight improvement in carcass grade and yield in the steers fed the supplement.

Pellets made from dehydrated Coastal Bermudagrass were compared with those made from sun-cured Coastal Bermudagrass. Both types of pellets were supplemented with a complex supplement and with 0, 30, or 60% cracked corn. No consistent differences were noted in steer performance due to type of pellet fed. Adding corn to the ration improved gain, dressing percentage, carcass grade, feed efficiency, and selling price. When properly supplemented, pellets made from good sun-cured Coastal Bermudagrass hay were equal in feeding value to pellets made from dehydrated Coastal Bermudagrass. However, adding corn to either type of pellet is desirable in the fattening process.

In a 140-day feeding trial the value of implanting steers with 30 mg. of diethylstilbestrol was determined when the steers were fed dehydrated or sun-cured Coastal Bermudagrass pellets with 30 or 60% cracked corn plus supplement. On the average, the diethylstilbestrol implants increased gain 14% and reduced feed needed per pound of gain by 11%. No consistent effect was noted on feed consumption, dressing percentage, or carcass grade. (AH d2-28)

3. Limited vs. free choice alfalfa hay. In studies at Fort Robinson, 340 heifers were used to determine the effect of feeding limited amounts of alfalfa hay as compared to free choice feeding on the feedlot performance of yearling heifers.

In the first trial 50 heifers were fed 2 lb. of alfalfa per day and 50 others were permitted to eat all that they would consume, which averaged slightly over 5 lb. per day. The grain ration (80% cracked corn, 15% dried beet pulp, and 5% soybean meal) was self-fed to all lots. Salt and steamed bone meal were fed free choice. The average daily gain and cost per 100 lb. of gain were for the limited and free choice groups, 2.35 lb., $17.63; and 2.34 lb., $19.81, respectively.

In the second trial a 4 lb.-per-day level was added to those used in the first trial. The same grain ration was fed. The average daily gain and cost per 100 lb of gain for the 2 lb., 4 lb., and free choice groups were 2.15 lb., $19.95; 2.50 lb., $18.75; and 2.37 lb., $19.70, respectively. (AH d2-21)

In a trial at Jeanerette, Louisiana, weanling heifers were fed rations to compare ground hay (Dallis and native Bermuda), corn silage, and grass silage (oats and rye grass). There was very little or no difference in gain or condition score due to treatment. All groups were given an adequate concentrate supplement. A trial with yearling heifers involved the evaluation of ground grass hay and grass silage. There was only 0.05 lb. difference in daily gain of the heifers and 0.3 of a grade difference in the condition score. These results indicate there is little or no difference in these roughages for wintering heifers. (AH d2-34)

D. Range and Pasture Management

1. Range supplementation studies. A project designed to determine the effect of age at first calving and level of winter feeding of beef cows on the breeding efficiency, longevity, and economic production of calves has been underway since 1948 at Fort Reno, Oklahoma, in cooperation with the Oklahoma Agricultural Experiment Station.

There were 117 heifers at the start of the experiment and the number of cows remaining in the herd and the average percent calf crops were: through 8 years of age, 107 cows, 94.9% born and 90% weaned; through 10 years of age, 99 cows, 94.5% born and 89.5% weaned; through 12 years of age, 81 cows, 93.8% born and 88.6% weaned; through 14 years of age, 57 cows, 91.9% born and 86.9% weaned.

The cows in this study began to decline in reproductive performance at 10 years of age, with a marked decline in cows 12 years of age or older. The decline in the older cows was one of failure to conceive.

There was no adverse effect of two-year-old-calving on the future reproductive performance of the heifers at 8, 10, and 12 years of age, respectively, 21.5%, 28.3%, and 33.3% of the cows had been open at least once.

The practice of culling open cows would have increased the calf crop for the following calving season by about 5% but would not have been effective in reducing the number of open cows in the herd in future years. The different winter levels produced marked differences in several economic traits but there were no consistent differences in any aspect of reproductive performance.

Estimates of milk production on more than 300 range beef cows representing both spring and fall calving herds were analyzed to determine some of the factors involved. There was a wide variation in milk production among individual cows (5.9 to 14.3 lb.). The body size of the cow had little influence on milk production. Milk production is a highly repeatable trait. The feed level prior to and during lactation had a marked influence on milk yields. (AH d2-12)

In an experiment at North Carolina, 40 yearling Hereford steers were used to compare grazing and soilage as methods of furnishing forage to fattening steers fed corn with added fat to limit concentrate intake. Grazing steers gained 0.2 lb. more per day while consuming 40% less concentrate than steers fed green chop. The steers consumed an average of 26 lb. of green chop per head daily. No large differences were observed in carcass characteristics. (AH d2-8)

E. Management Practices

1. Management of cattle and pastures for beef production. Creep feeding experiments carried on for 4 years at Brooksville, Florida, with Angus,

Hereford, Brahman, and Santa Gertrudis breeds and a Brahman-Angus group showed wide breed differences. The creep-fed calves showed an advantage of 15 lb. over the noncreep-fed calves at weaning. The average increase in weight of the creep-fed over the noncreep-fed was for Angus 24 lb., Hereford 34 lb., Brahman -3 lb., Santa Gertrudis 14 lb., and Brahman-Angus 11 lb. While the creep-fed calves made more gain during the preweaning period, the opposite was true during the post-weaning period. At 18 months of age, the noncreep group averaged 661 lb. while the creep group averaged 652 lb. Thus, by 18 months of age the advantage of creep feeding had disappeared.

In a trial at Brooksville, Florida, 24 steers were full fed on pasture for 210 days, one-half of the steers were given 25,000 U.S.P. units of vitamin A per head daily. The vitamin A steers gained 0.04 lb. per day more and were almost a third grade fatter than the control group. The vitamin A steers had a brighter, cleaner hair coat, and looked better than the steers in the control group. (AH d3-2)

The value of corn silage and limited concentrates for feeding cull beef cows was studied at Jeanerette, Louisiana. Cows receiving silage and concentrates gained in condition from cutter to utility while the non-fed group remained in the same condition. The market value of the fed cows increased about 2 cents per pound. There was no increase in value of the non-fed cows. (AH d2-34)

2. Beef production from beef, dual purpose, and dairy steers. This experiment is being conducted in cooperation with the Dairy Research Branch and Meat Quality Laboratory to study several systems of feeding and management as related to the economy and value of beef from dual purpose and dairy cattle.

The first replication has been completed in which Holstein, Milking Shorthorn, Jersey, and Angus were fed the first six months of life either on a high plane of nutrition involving large quantities of milk or a low plane representative of dairy replacement feeding practices. For the second phase, steers of each breed and previous nutritional plane were subdivided into four groups. These were: (1) slaughtered at six months to determine body composition, (2) high concentrate ration, (3) all-hay ration, or (4) all-hay ration for most of the period followed by a finishing period on the high concentrate ration. Average 180-day weights were 440 and 220 lb. on the high and low planes, respectively. Holsteins gained proportionately faster and Milking Shorthorns slower on the low nutritional plane during the first six months. Holsteins gained most rapidly on all rations in both phases followed by Milking Shorthorn, Angus, and Jerseys. Steers fed at the lower level during the first six months gained more rapidly and more efficiently during the second phase. Tenderness and palatability of the meat, fat content, and lean content were related to the feeding regimes during the second phase. In fatness of carcasses the breeds ranked Angus, Milking Shorthorn, Jersey, and Holstein. The Angus ranked highest and Milking Shorthorn lowest in tender-

ness. The Angus was the most efficient in fat production. The second replication has been started with some modifications in the feeding regimes for the first six months. The Angus were replaced by Herefords for this trial. The milk replacer has been increased 20% and a calf starter is being fed for the first 60 days, then replaced with the calf grain which is fed up to 4 lb. per day. The maximum amount of milk being fed is 30 lb. per day. The average daily gains during the first six months for Herefords, Holsteins, Milking Shorthorns, and Jerseys on milk are 1.91, 2.78, 2.43, and 1.81 while the gains on milk replacer are 1.00, 1.54, 1.34, and 1.14. These rates of gain are higher than those in the first replication. (AH d3-6) (Also see Area 5 c-5)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Digestion and Metabolism

Crookshank, H. R. 1962. Mineral variations of rations and animal performance. Proc. Tex. Nutr. Conf. p. 24. (AH d2-31)

Crookshank, H. R. 1962. Ovine urinary calculi and pelleted ration. J. Anim. Sci. 21: 933. (Abstr.) (AH d2-31)

Crookshank, H. R. and Robbins, Joe D. 1962. A reciprocal relationship between urinary excretion of magnesium and phosphorus in wether lambs. Nature 196: 1343. (AH d2-31)

Gutierrez, J. and Davis, R. E. 1962. Isolation of saponin-digesting bacteria from the rumen of bloating cattle on Ladino clover pasture. J. Anim. Sci. 21: 819-823. (AH d2-24)

Gutierrez, J., Essig, H. W., Williams, P. P. and Davis, R. E. 1963. Properties of a slime isolated from the rumen fluid of cattle bloating on clover pasture. J. Anim. Sci. 22: 506-509. (AH d2-24)

Gutierrez, J., Williams, P. P., Davis, R. E., and Warwick, E. J. 1962. Lipid metabolism of rumen ciliates and bacteria. I. Uptake of fatty acids by Isotricha prostoma and Entodinium simplex. Appl. Microbiol. 10: 548-551. (AH d2-26)

Lyford, Jr., A. J., Smart, Jr., W. W. G., and Matrone, G. 1963. Digestibility of alpha-cellulose and pentosan components of the cellulosic micelle of fescue and alfalfa. J. Nutr. 79: 105-108. (AH d2-8)

Williams, P. P., Gutierrez, J., and Davis, R. E. 1963. Lipid metabolism of rumen ciliates and bacteria. II. Uptake of fatty acids and lipid analysis of Isotricha intestinalis and rumen bacteria with further information on Entodinium simplex. Appl. Microbiol. 11: 260-264. (AH d2-26)

Wise, M. B. and Barrick, E. R. 1963. Green chop vs. pasture for finishing steers fed corn with fat to limit intake. ANS Rpt. No. 117, A.H. Series No. 87. N. C. Agric. Expt. Sta. (AH d2-8)

Wise, M. B., Gross, H. D., Barrick, E. R. and Evans, Jr., Hervey. 1963. The influence of supplemental energy and protein on performance of steers grazing nitrated Coastal Bermuda. ANS Rpt. No. 116, A.H. Series No. 86. N. C. Agric. Expt. Sta. (AH d2-8)

Yarns, D. A. and Putnam, P. A. 1962. Rumen factors affecting salivary secretion rate. J. Anim. Sci. 21: 1032. (Abstr.) (AH d2-14)

Concentrates

Beardsley, D. W., McCormick, W. C. and Southwell, B. L. 1963. Stilbestrol implants for steers fed Coastal Bermudagrass pellets with and without corn. Prog. Rpt. June 27, 1963. pp. 51-55. (AH d2-3)

Putnam, P. A. and Davis, R. E. 1962. Ration effect on drylot steer feeding patterns. J. Anim. Sci. 21: 1009. (Abstr.) (AH d2-28)

Putnam, P. A. and Davis, R. E. 1963. Feeding pelleted rations to beef cattle. USDA, ARS, Prod. Res. Rpt. No. 69. (AH d2-28)

Putnam, P. A. and Davis, R. E. 1963. Ration effects on drylot steer feeding patterns. J. Anim. Sci. 22: 437. (AH d2-28)

Range and Pasture Management

Beardsley, D. W., McCormick, W. C. and Southwell, B. L. 1963. Hypomagnesemia and grass tetany in cattle grazing temporary winter pasture. Ga. Agric. Expt. Sta. Mimeo. Series NS 165. (AH d2-3)

Burns, W. C. 1963. The effect of creep feeding on weaning and post-weaning performance of calves. Ann. Prog. Rpt. A.H. Beef Cattle Res. Sta., Brooksville, Fla. p 10 and Mimeo. pp. 1-5. (AH d3-2)

Pope, L. S. Smithson, L., Stephens, D. F., Pinney, D. O., and Velasco, M. 1963. Factors affecting milk production of range beef cows. ibid. pp. 69-77. (AH d2-12)

Smithson, L., Pope, L. S., Stephens, D. F., and Pinney, D. O. 1963. Alternate low and high winter feed levels on growth and performance of beef heifers. ibid. pp. 42-49. (AH d2-12)

Turman, E. J., Pope, L. S., and Stephens, Dwight. 1963. The lifetime reproductive performance of a Hereford cow herd. Okla. State Univ. Expt. Sta. Misc. Public. 70. pp. 15-24. (AH d2-12)

Turman, E. J., Pope, L. S., Watkins, B. J., Pinney, D. O., McNutt, D. D., and Stephens, D. F. 1963. The reproductive performance of Hereford heifers on different levels of winter feeding and summer grazing, ibid. pp. 28-35. (AH d2-12)

AREA NO. 5: DAIRY CATTLE - BREEDING

Problem. Dairymen need information on genetic methods for increasing the efficiency of milk production and modifying milk composition, as well as other economic traits, in order to reduce unit costs and meet the future market demands. Precise information is needed on the relative importance of performance traits, the nature of their inheritance and their response to selection and specific systems of mating. Recently advanced genetic methods, such as those utilizing heterosis and specific and general combining ability, need to be evaluated as procedures for more rapid improvement of milk production or other important traits.

USDA PROGRAM

This is a continuing program conducted by geneticists on basic and applied studies of the inheritance of the dairy cow, including experiments designed for evaluating the application of advanced genetic concepts to dairy cattle improvement. The work is in progress at Beltsville, Maryland, and cooperatively with 14 State experiment stations and laboratories in nine foreign countries. Several of the studies contribute to the North Central and Southern regional dairy cattle breeding projects. Cooperation is also carried out with the National Association of Artificial Breeders and with the various dairy cattle breed registry organizations.

The Federal scientific effort devoted to the research in this area totals 18.2 professional man-years. Of this number, 6.0 are devoted to genetics and interrelations of performance traits, 11.0 to selection and systems of breeding, and 1.2 to program leadership.

A grant with the Agricultural Research Center, Tikkurila, Finland, provides for research on the breed differences regarding the antigenic properties of cattle blood, their inheritance in relation to economic characteristics and genetic origin of the breeds. Its duration is for four years, 1961-1964, and involves PL-480 funds with a $61,804 equivalent in Finnish Finmarks.

Another grant with the Division of Investigaciones Agropecuarias, Ministry of Agriculture, Bogota, Colombia, supports work on the evaluation of the native breed, Costeno Con Cuernos, and Holsteins and Brown Swiss when mated and selected for dairy traits under the hot and humid conditions of Northern Colombia. The duration of the grant is for five years, 1962-1967, and involves PL-480 funds with a $246,000 equivalent in Colombian pesos.

Two PL-480 projects (also reported in area 6) S3 AH-7, at Sao Paulo, Brazil, and A7 AH-1, at Izatnagar V. P., India, are in effect and are pertinent to this area.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits

1. The genetics of feed utilization. These studies were undertaken to determine if there are inherited differences in the ability of growing and lactating dairy cattle to utilize feed. The research is being conducted at Beltsville and in cooperation with the Agricultural Experiment Stations of Montana, Utah, and Tennessee. The Tennessee study is a contributing project to the Southern Regional Dairy Cattle Breeding project (S-49).

(a) Genetic ration interactions in feed efficiency and consumption. At Lewisburg, Tennessee, a total of 134 first lactation Jersey cows have completed 305-day production records; 67 on roughage only and 67 on grain plus roughage.

The average mature equivalent fat corrected milk (ME FCM) yield for the roughage group was 9,585 pounds as compared to 11,884 pounds for the roughage plus grain group. The roughage group produced 80.7% as much ME FCM as the roughage plus grain cows. Individual sire groups ranged from 75.7% to 83.4%.

Analyses of these data showed that there were highly significant differences between rations in milk, fat, and FCM production, and in hay and silage consumption. There were also highly significant differences between sires within rations for these measurements. The sire by ration interaction was not significant for either measure of production. The sire by ration interaction was highest in the ME fat yield where 12% of the within ration variation was due to interaction. This, however, was not significant. Analyses concerning the no grain group, where differences between sires in hay and silage consumption were estimated, showed that there were differences between sires in the ability of their daughters to consume roughage. This between sire difference in roughage consumption was in the form of silage and not hay. These preliminary results indicate thet there is not an interaction between sires and rations, but there are differences in the ability of daughters of different sires to consume forage.

At Utah, a total of 94 first lactation Holsteins has finished production records, 45 on forage only and 49 on forage plus grain. Six sire groups originated at Huntley, Montana, and 2 sire groups originated at the Utah Station. The average ME FCM yield of the cows fed hay only was 9,559 pounds as compared to 13,425 pounds for the cows fed grain and forage. The hay only cows produced 71.2% as much as their half sibs fed forage and grain. Individual sires varied from 56.9% to 76.8%. The results of a two-way analysis of variance using weighted means indicated significant differences among sires and systems of feeding. The sire by system interaction, however, was not significantly different from zero. These results parallel those from the Jersey data at Lewisburg, Tennessee. The only appreciable difference in the two studies is the higher proportionate production of Jerseys on all

forage ration. It is of significant interest to note that the Jerseys on forage only produced almost the exact amount of FCM as did the Holsteins at Utah (9,585 pounds for Jerseys and 9,559 pounds for Holsteins). These results indicate that Jerseys are more efficient than Holsteins in utilizing forage for milk production. (AH gl-4)

(b) Ration effects on production efficiency. The research in progress at Beltsville, to determine the value of certain feeding regimes in estimating genetic differences in feed efficiency among cows, is being continued. At the present time 25 cows fed at a constant rate have completed 42 lactations. Their average FCM yield was 13,759 pounds with a corresponding feed efficiency of 1.978. The standard deviation of FCM yield and feeding efficiency was 1,323 and 0.27, respectively. Twenty-seven cows fed according to production and maintenance requirements have completed 43 lactations. These cows average 15,084 pounds of FCM and their efficiency of feed utilization was 1.947. The standard deviation of FCM yield and feed efficiency was 2,648 and 0.19, respectively. The difference in yield of 1,325 pounds of the group fed according to requirements was probably due in part to the difference in the average energy intake among the groups. This group received an average of 795 therms of additional energy. There was more variation in FCM yield among cows in this feed group. This would be expected when feeding according to production and maintenance requirements as opposed to feeding at a constant level of energy intake regardless of production and maintenance requirements. The intra class correlations (repeatability) between successive lactations for FCM yield was 0.385 and 0.533 for the constant fed and requirement fed groups, respectively. The repeatability of feed efficiency was 0.283 and 0.449 for the constant fed and requirement fed groups, respectively. The requirement fed group was more persistent and gained more weight during the lactation than the constant fed groups.

(c) Comparisons of ad-libitum feeding and "standard" feeding of dairy cattle. The study on ad libitum feeding of grain, alfalfa hay, and corn silage to 19 second lactation dairy cows is now completed. This study was initiated to study the effects of unlimited feed intake on feed efficiency and milk production. The results of this group were compared against a like number of contemporaries fed at approximately 110% of Morrison's maximum net energy requirements for production and maintenance. The FCM yield, percent SNF, and persistency of production were 13,234 and 13,232; 8.90 and 8.77; 0.70 and 0.68 for the ad libitum and contemporary groups, respectively. These differences were not significant. Body weight, body weight change, therms of estimated net energy consumed, and feed efficiency were 1,486 and 1,409; 248 and 164; 8,671 and 7,397, 1.51 and 1.79 for the ad libitum and contemporary groups, respectively. These differences were significant.

The standard deviation for milk yield was 3,347 and 2,457 for the ad libitum and contemporary groups, respectively. It is apparent that there was considerably greater variation among the cows fed ad libitum. Three of the 19 cows failed to complete a ten-month lactation and milked less than in their first lactation; yet consumed nearly 5% more total energy. Two others,

although completing 10 months, produced less than their first lactation yield, but consumed 32% more total energy. Four cows produced less than their expected second lactation yield. The remaining 10 cows produced from 104 to 133 percent of their expected second lactation yield based on age correction factors.

The ad libitum group consumed 17 percent more total energy on the average than the contemporary group, with a range of 104-151 percent of Morrison's maximum net energy requirements for maintenance and production. Seventy-one percent of the total energy consumed by the ad libitum group was in the form of concentrates. As a result of the additional energy consumed, and because of the variation in response for yield, the ad libitum group gained more weight and was less efficient than the contemporary group. The standard deviation for therms of energy consumed was 1,304 and 448 therms for the ad libitum and contemporary groups, respectively. This difference was significant and indicates the variation among cows in their ability to consume unlimited quantities of feed.

In comparing the standard deviations for each of the production traits studied, from the first to second lactation of the ad libitum group, there was a significant increase in all except body weight. During the first lactation, these cows were fed according to requirements. The standard deviation of FCM yield, persistency, total therms of energy consumed; body weight changes, and feed efficiency increased by 1,715 pounds, 0.04%, 686 therms, 36 pounds and 0.08 therms of energy per pound of FCM yield, respectively. When the standard deviations for the same traits were compared between the first and second lactations of the contemporary groups, there were no significant changes. These results are a further indication of the variation among cows in their response to unlimited feed intake.

The ad libitum cows were less efficient in their second lactation (1.51) than in the first lactation (1.69). Previous work has shown efficiencies to increase in successive lactations, which occurred in the contemporary group (1.69 to 1.79) from first to second lactation.

Since there was an increase in the amount of energy consumed with no difference in FCM yield among the groups during second lactations, a decrease in gross efficiency would be expected. The increase in the variation in body weight change is also a reflection of the additional energy consumed. Once the individual requirement for maintenance and production was met, the additional energy was being utilized in laying down additional flesh.

Several rather important factors have evolved as a result of these studies. The first is the apparent variation among cows in both their response to ad libitum feeding and the variation in cattle in their ability to consume large quantities of feed with varying proportions of concentrates to roughages. Secondly, it would appear that ad libitum feeding may be a useful tool in the genetic aspects of feed utilization in dairy cattle, because of the magnitude of the between cow differences in their response to ad libitum

feeding. Third, it points out rather clearly that appetite "per se", although important, is not the only limiting factor in milk production. (AH gl-4)

2. Effects of lactation stage and number on type ratings. A group of 200 first lactation Holstein cows, in three different Ohio herds, were evaluated for type on a complete breakdown basis including ten categories. Evaluations were made independently and simultaneously by two persons, three months after calving, eight months after calving, and at approximately the middle of the dry period following the first lactation. For each evaluation period, the scores of the two classifiers were averaged. Data were analyzed by the analysis of variance technique to determine the relative importance of stage of lactation, and correlation values were used to estimate repeatabilities.

Categories significantly affected by stage of lactation were middle and loin, rump and thigh, udder attachment, and breed character. As lactation progressed, type scores for these categories increased. For the category dairy character, there was a gradual decrease in type score in all herds as lactation progressed. This decrease, however, was not significant at the .05 level of probability.

Correlations between type score and milk production were computed for each of the periods (3 months after calving, 8 months after calving and dry). The type categories of middle and loin, rump and thigh, and breed character differed significantly between the periods. These results indicate the errors involved when type ratings are made on cows in different stages of lactation. Other correlations were computed as follows: First lactation type vs. first lactation production 0.024; first lactation type vs. mature production 0.085; mature type vs. mature production 0.155; and 3 months after calving type vs. 3 months after calving production 0.147. These correlations are small and have little value in predicting milk production. (AH gl-2)

3. Relation between body form and milk production. Data collected during the years 1949 through 1961 from the Grand Rapids, Morris and Rosemount Experiment Station dairy herds were analyzed to study the relationships between certain body measurements and milk yield. Estimates were obtained from 157 daughter-dam pairs and from paternal sister data representing from 371 to 452 progeny of 71 sires. Body measurements studied were weight, height at withers, chest depth, body length, heart girth and paunch girth. Measurements were taken at 3 months, 6 months, 12 months, and 18 months of age, and at 3 months after first calving.

Most of the combined estimates of the genetic correlations between body measurements and production were positive and on the order of .10 to .40. However, with the exception of the correlation between 12-month weight and milk yield, none of the estimates were significantly different from zero. The genetic correlation between 12-month weight and milk yield was estimated to be $.434 \pm .185$.

Analysis of the body measurement data suggests that no genetic antagonism exists between milk yield and measurements of body size. Dairymen interested in feeding dairy steers can expect their selection for milk yield to result in no decrease in the gains made by offspring of their better yielding cows. (AH gl-1)

4. Early sire evaluation by the use of udder palpation and body weights. At Ohio, data on 55 sires which had production records on 1,216 daughters were used to determine the accuracy of an early sire evaluation based upon the udder palpation information available on his five-month old daughters.

Future production of the daughters was predicted from the udder palpation information by the use of five prediction equations developed in the NC-2 and S-3 interregional bulletin (1960). The resulting predicted production was averaged by year of daughter's birth for each sire having four or more palpated daughters born in one year. Thus, 149 predicted daughter averages were available for comparison with the daughters' actual performances.

The predicted daughter averages were correlated with the actual daughter averages on a within herd and within year basis. The correlations for two of the prediction equations were significantly different from zero (at 1 percent level). However, analysis of the various components of the indexes indicates that the majority of this association is a result of the inclusion of the herd average and dams production in prediction indexes. It is concluded that udder palpation information is not a reliable method of obtaining an early sire evaluation. (AH gl-3)

5. Meat production from beef, dual purpose and dairy steers. This study was initiated in cooperation with the Beef Cattle Research Branch to determine the relative merits of various breeds of cattle and different management systems in the production of meat.

The first relication has been completed of this experiment in which Holstein-Friesian, Milking Shorthorn, Jersey, and Aberdeen-Angus steers are being fed during the first six months of life (phase 1) either on a high or low plane of nutrition and then placed on 3 types of rations per group until slaughter (phase 2). Average 180-day weights were 440 and 221 pounds on the high and low planes, respectively. Holsteins gained most rapidly on all rations in both phases followed by Milking Shorthorns, Angus, and Jerseys in that order. Holstein-Friesians gained proportionately faster and the Milking Shorthorns slower on the low nutritional plane during the first six months. Breed X ration interactions in the second phase and at slaughter were significant only for daily gain, thickness of fat over the rib eye and percent internal fat. Animals fed at the lower level during the first six months gained more rapidly and more efficiently during the second phase. Carryover effects of first six-month treatment on carcass grade and composition were small and non-significant. The lean, after cooking to an internal temperature of 140°F. (60°C.), was significantly more tender by both Warner-Bratzler shear and taste panel for those on the high plane the first six months. Tenderness

and palatability of the meat, fat content, and lean content were related to the feeding regimes during the second phase. Those receiving more concentrates had more fat, less lean, and more tender and palatable lean. In fatness of carcasses the breeds ranked Aberdeen-Angus, Milking Shorthorn, Jersey, and Holstein-Friesian. The Angus ranked highest and Milking Shorthorn lowest in tenderness. Ration differences in efficiency expressed as live weight gain or pounds of lean produced per therm of energy consumed were small. Ration effects were significant for pounds of fat produced with the high level nutrient rations producing the most fat. Breeds were significantly different in efficiency of both gain and lean production and ranked in the order of Holstein-Friesian, Milking Shorthorn, Aberdeen-Angus and Jersey. The Aberdeen-Angus was the most efficient in fat production. (AH d3-6)

6. Meat production from dairy steers. This study was designed to evaluate the variation among sire groups in meat production characteristics when selection is made for milk yield. It will also measure the genetic relationship between meat and milk production. The project is cooperative with the Experiment Stations of Pennsylvania and West Virginia. At Pennsylvania State University, a comparison was made concerning growth and carcass evaluation on both Holstein steers and bulls. Groups of 15 bulls and 15 steers were fed out to weights of 800 and 1,000 pounds. The average daily gain of bulls was significantly greater than steers from birth to slaughter at both 800 and 1,000 pounds ending live-weight. The days required to reach slaughter weights were significantly less for bulls than for steers. The steers, however, had higher dressing percentages than bulls at both slaughter weights. The bulls were larger in rib eye area and had superior percent of desired cuts than did the steers. Steers were superior in percent of hind quarters as compared to bulls.

7. The genetics of blood antigens in dairy cattle.

(a) Blood group segregation and fertility effects. At the the Ohio laboratory, a study was made of the possible effects on fertility of blood group segregation. Five bovine blood groups (A, F-V, L, S, and Z) were evaluated in Holstein cattle to determine whether blood group incompatability existed. Incompatability was based on the difference between observed and expected allelic segregation to female offspring. The only system deviating significantly from the expected allelic segregation was the F-V system. This deviation ($P = 0.005$) favored F/F over F/V type offspring from the mating type F/V x F/F (615 to 515, respectively). Preliminary evidence indicated that postnatal removal prior to typing was not a contributing factor. Comparisons of the percent delayed returns (28 days) for total pregnancies and calves born for total services between the mating types F/V x F/F and F/F x F/F were 20.4 to 17.7 percent and 50.7 to 48.5 percent, for 642 and 706 pregnancies and 1,197 and 1,017 services, respectively. These differences were not significant although a trend of a greater delayed return rate may have been indicated with the former mating type.

No discrepancy was found in allelic segregation of the F/V x F/V mating types.

(b) Transferrin types and their relation to fertility and production. Another study at Ohio, associated bovine transferrin types with fertility and production. Samples of bovine blood from 1,116 animals were used to determine transferrin (Beta-globulin) types. Disc electrophoresis procedures were developed which would accommodate bovine bloods. Genes frequencies for transferrin types among 456 Holstein females in one Ohio NC-2 Project herd were TrA-28.8%, TrD-62.5%, and TrE-8.7%. Parental comparisons indicated that transferrins were controlled by a three allele system without dominance. Age of the animal (one day to five months) had no detectable influence on transferrin type. The frequency of transferrin types appeared similar for both sexes. Analysis of 520 sire-dam-daughter combinations and 32 supposedly identical twin pairs indicated that the transferrin data are very valuable in supplementing blood antigen data for identification purposes. Information on several hundred matings indicated no easily detected association between transferrins and fertility. A significant association between transferrin type and milk production was demonstrated (215 cows). Animals without TrE were better producers than those with TrE.

(c) Blood antigen studies in Finland. The Pl-480 project in Finland on bovine blood antigens is in its third year. The Finnish laboratory has produced 30 blood typing reagents and is now practically self-sufficient with regard to these typing fluids. In the development of reagents at least one new antigenic factor, SF_3, was discovered. This factor may be controlled by a previously undiscovered locus. It seems to be inherited independently of nine of the eleven known loci.

Further studies of blood groups in relation to a recessive gene for hairlessness have been made. The previous indication of association between the gene for hairlessness and blood factor L^1 was not confirmed. It now appears that the gene for hairlessness is not associated with blood groups at nine loci which have been studied. Furthermore, studies in Finland failed to indicate any association between the dominant gene for polledness and blood groups.

A survey was made to determine the frequency of incorrect parentage. A random sample of 588 young bulls revealed that 2.38% had incorrect pedigrees. In a similar sample of 718 young daughters of AI sires 5.32% had incorrect pedigrees. The combined figure is 3.98%. (AH gl-6) (PL-480-E8-AH-1)

8. Genetics of milk constituents. The national cooperative effort to obtain data on milk, milk fat, solids-not-fat (SNF) and protein production of individual cows is continuing. Plans are being made for a preliminary analysis of data to study genetic and non-genetic influences which affect milk composition. Several thousand lactation records are available from all four regions of the U. S. and they are to be sent to Virginia Polytechnic Institute for analysis. Expectations are that for the Holstein breed

at least, there will be over 5,000 lactation records.

(a) Evaluation of testing methods. Interest in testing methods, particularly for protein, has heightened considerably during the past year. The dye-binding methods for protein determination are widely used. They are good methods under laboratory conditions where the variables involved can be carefully controlled. Considerable research needs to be done, however, before a single standard method can be recommended for widespread use in protein testing, as the Babcock test is used for milk-fat testing. Dairy Cattle Research Branch personnel are cooperating with the American Dairy Science Association and the Association of Official Agricultural Chemists to find out how reproducible the dye-binding methods are and to develop a standard method. In the first attempt at collaborative testing, twenty samples of dry milk powder were sent out from Beltsville in the fall of 1962. Collaborating laboratories were asked to test the samples (all laboratories received the same samples) by the standard Kjeldahl method for protein as well as their dye-binding method. Eight laboratories tested the samples by the Kjeldahl method. The average differences from expected were .23 and .24 percent for two of the laboratories (sign of difference not considered). The averages for the other six laboratories were between .046 and .075. The range of values reported for any one sample by these six laboratories averaged .21.

Six laboratories tested the samples by the Orange G dye-binding method. The range of values reported for any one sample averaged 1.02 percent. One laboratory reported results considerably higher than the others and when its results were excluded the average dropped to .42 percent. Four laboratories used the Amido Black dye-binding method with the range of values reported for any one sample averaging .65 percent. Deviations from expected were not calculated since the dye-binding values were taken from curves established with whole milk and there was a difference in the dye-binding capacity of the powder as compared to fresh milk.

One of the problems encountered in the dye-binding methods is variation in dye purity. During the past year, the Color Certification Branch, Division of Color and Cosmetics, Food and Drug Administration (FDA) has cooperated by assaying dye samples. This work revealed considerable variation in the pure dye content of different lots of dye. Three different experiments at Beltsville have indicated that the practice of standardizing dye solutions by making them up to the same optical density may lead to errors. In the most recent and extensive study, solutions were made up from four different batches of Orange G dye. The FDA analysis showed the preparations to contain 96.0, 95.9, 91.3 and 96.2 percent pure dye, respectively. The four solutions were prepared to give the same optical density. Careful comparisons were made with each solution being read several times on three different occasions over a 2-day period. Milk samples for each of ten cows were tested in triplicate with each of the four dye solutions. Twelve tests were done on each cow's milk for a total of 120 tests. Analysis of variance showed that differences due to cows and dyes were highly significant. There was no evidence

of cow x dye interaction. The overall mean protein percentages for the four dye solutions were 3.39, 3.42, 3.46, and 3.50, respectively. This variation could not be explained on the basis of percent pure dye since the solutions giving mean protein percentages of 3.46 and 3.50 had 91.3 and 96.2 percent pure dye, respectively, while 3.39 and 3.50 were the mean protein values for the solutions with 96.0 and 96.2 percent pure dye. The conclusion is that specific unknown impurities in the dye are responsible for the observed differences. More work is needed to find out what these impurities are and the extent to which differing amounts of them affect optical density.

(1) Interrelationship of milk constituents. At Beltsville, records have been summarized on 147 cows that have completed lactations in which their milk was tested monthly for fat, SNF and protein. Of these, 124 were Holstein, 11 were Brown Swiss-Holstein crossbreds and 12 were Ayrshire-Holstein crossbreds. There were 183 lactation records. These records averaged 15,477 pounds of milk, 4.09% fat, 633 pounds of fat, 8.86% SNF, 1,371 pounds of SNF, 3.13% protein and 485 pounds of protein (2X 305 ME records). The following correlations were calculated from lactation averages on a within sire basis: milk and fat % -0.27, milk and SNF % -0.03, milk and protein % -0.18, fat % and SNF % 0.50, fat % and protein % 0.34, and SNF % and protein % .31. The correlation between SNF % and protein % is considerably lower than expected in comparison with reports from other workers.

Correlations among these same variables were calculated for each of nine sire groups (7 to 17 daughters per sire with 9 to 21 records per sire group). Although these are preliminary analyses on relatively small numbers, the results show different relationships of milk constituents between bulls. Of the 54 correlations calculated, only 11 were significantly different from zero. The significant sire group correlations were: milk and fat % -0.50 amd -0.50; milk and SNF % 0.44 and -0.71; fat % and SNF % 0.48, 0.70, 0.71, 0.74 and 0.86; fat % and protein % 0.48; and SNF % and protein % 0.63. A further preliminary indication of variation between sire groups is seen in the sire group means for fat, SNF and protein %. One group of 10 daughters of Holstein cows by a Brown Swiss bull averaged 4.57% fat, 8.90% SNF and 3.09% protein. The sire group with the lowest average fat % (3.79) had an average SNF % of 8.77 and an average protein % of 3.13. This was a purebred Holstein group of 13 daughters with 16 records.

At Michigan State University, the composition of milk has been measured for about 10,000 completed lactations. Preliminary analysis shows almost perfect correspondence between pounds of milk and pounds of protein, lactose and minerals produced in completed lactations. Variation in percent solids of milk excluding fat appears similar to the way and amount percent fat varies with the age of the cow and with the amount of milk produced. Genetic relationships between milk and its components are being examined.

(b) Genetically controlled protein variants. Additional studies have confirmed the previously reported suspicion that genetically controlled variation occurs in α'_s-casein. This work is done in cooperation with the

Eastern Utilization Research and Development Division. Caseins from 1,378 individual cows were studied and three major α_s-casein variants were identified by starch-gel-urea electrophoresis. They are designated A, B, and C in order of decreasing mobility. Family studies indicate that an autosomal series of three genes, α_s-C_n^A, α_s-C_n^B, and α_s-C_n^C, controls the variation in α_s-casein. Each gene causes the appearance of a particular form of α_s-casein and there is no dominance. α_s-casein B is most common. Seventy-two percent of all animals sampled had only B in their milk. The other percentages were: A only, 0.1; A and B, 5.9; A and C, 0.4; B and C, 18.6; and C only, 2.5. Ninety-eight Ayrshires were sampled and all had B only. All three variants, A, B and C, were found among the 542 Holsteins sampled. Only B and C have been found so far in Brown Swiss, Guernsey and Jersey cattle. α_s-casein C is more common in Guernseys and Jerseys than in any of the other breeds.

β_s-casein types were also determined on the 1,378 milk samples. The three types, A, B, and C were found and family studies confirmed.

Further studies of additional animals are planned to determine if there are any associations between these polymorphisms and other traits.

(c) Flavor differences in milk from individual cows. Milk samples for organoleptic evaluation were taken monthly throughout lactation from 74 cows. Samples were split, pasteurized and stored at 40°F. until a panel of 10 judges at the Eastern Utilization Research and Development Division evaluated them for flavor. One subsample was judged by the taste panel on the morning following collection (fresh samples), and the other was judged after 7 days of storage (stored samples).

Least squares analysis indicated that there were significant differences associated with season for cooked, feed, oxidized, salty and total score flavors. Stored samples showed differences in cooked, feed, flat, oxidized, salty and total score. Milk produced during April-July period had the best flavor. There were significant changes associated with stage of lactation in the following: feed, oxidized, salty and total score in fresh samples and feed, flat and salty in the stored samples. Higher quality milk was produced during the first half of lactation. The analysis also indicated important differences in flavor of milk produced by individual cows and between groups of half-sibs.

Within cow correlation analysis showed that pounds of milk, percent fat, percent solids-not-fat, quantity of feed consumed, air temperature and relative humidity had little relation to total score or specific criticisms of either the fresh or stored samples. The within-cow correlation between fresh and stored total score was only 0.19. (AH gl-5)

B. Selection and Systems of Breeding

1. Comparisons of inbreeding and outbreeding. This research was undertaken to determine the effects of inbreeding, outbreeding, and interline

crossing on production and other economic characteristics of dairy cattle. It is conducted cooperatively with the Wisconsin Agricultural Experiment Station and is a contributing study to the North Central Regional Dairy Cattle Breeding Project. The development of crosses among six inbred lines of Holstein-Friesian cattle and maintenance of controls have been continued. The effects of mating systems on production traits were evaluated. Analysis of the control group showed non-significant variations among years and among season of calving. Therefore, all analyses were performed without consideration of yearly and seasonal effects.

(a) Interaction effects. Analysis of all traits between different systems of mating for each line of sire and that between lines for each mating system indicated the existence of system X line interaction, i.e., the differences among mating systems were not consistent from line to line. In general, inbreeding decreased the mean value of all traits except fat percent and age at first calving. The superiority of the two-line cross and three-line cross groups over the inbred groups can be interpreted as an expression of heterosis in these traits.

(b) Regression estimates of inbreeding effects. The data were divided into two sets. Set one consisted of outbreds and all inbreds. Set two included the same inbred animals and the two-way linecrosses. Within-line estimates of inbreeding effects on milk production were -54.9 and -67.1 pounds of milk per each 1% of inbreeding for the two sets of data, respectively. Corresponding estimates for butterfat were -1.7 and 2.7 pounds. Fat percent and age at first calving showed little effect of inbreeding. Body weight at first calving was decreased by 2.2 pounds in set one and 3.2 pounds in set two for each 1% of inbreeding.

(c) Changes in variance and covariance component estimates under different systems of mating. The total variance, between-line variance and within line variance components tended to increase with inbreeding and decrease with crossing in most traits. However, the within-line variance for fat percent indicated a slight decrease with inbreeding. The covariance between different traits on a between-line basis showed a tendency to increase with inbreeding. The daughter-dam covariance components estimated on a within-line basis in which daughter and dam were produced under the same or different mating system, showed an increase in milk and fat but a decrease in fat test with inbreeding. Data from crosses of the inbred lines, when compared with the estimates for the outbred group, yielded larger estimates of the covariance components for milk and fat with little change in the values for fat test. The biological interpretations of such changes are obscure because of the sampling error of the estimates, the unknown genetic situation of the traits under study, the presence of dominance, and possibly other reasons.

(d) Genetic variation in body size at birth. The variation of body weight and measurements of 559 single-born Holstein calves of both sexes at birth was studied. Least-squares estimates of sex and parity effects were

used for adjustment of all measurements to a first-parity-female-calf basis. The mean value of each trait decreased and the total variance increased with inbreeding. The changes of the within-line variances were not consistent, but the between-line variances tended to increase in the inbred groups. When outbred calves and inbred calves from outbred dams were compared, inbreeding depression was highly significant in body weight, heart girth, hip width and shinbone circumference. Significant heterosis was shown in all measurements except shinbone circumference when inbreds and two-line crosses (both from inbred dams) were compared. A regression analysis of data from all outbred and inbred calves indicated significantly heterogeneous effects of inbreeding among sire lines in chest depth, hip width, head length and width. The intra-line regression was -0.24 $\pm$ 0.05 pounds and -0.06 $\pm$ 0.01 cm for each increase of 1% inbreeding in birth weight and heart girth, respectively.

(e) Factors affecting multiple ovulations. A total of 3,076 ovulations determined by palpation in 728 animals covering six sire lines, two systems of mating (outbreds and inbreds, with inbreeding coefficient not exceeding 40%) and three parities were analyzed. The study was limited to observations during 90 days from the day of calving in cows or from 12 months of age in heifers. Ovulations which occurred in service periods characterized by cystic ovaries ("cystic" service periods) were studied separately. The incidence of multiple ovulations in noncystic and cystic service periods was 4.2% and 12.9%, respectively. Analysis of ovulations in noncystic service periods by the method of least squares showed that outbreds had a significantly higher percentage of multiple ovulations than inbreds (5.2% vs. 3.2% $P < 0.05$). There was a significant increase in the incidence of multiple ovulations with parity (from 2.9% in heifers to 5.9% following the second calf $P < 0.05$). The influence of sire line was nonsignificant. Multiple ovulations were not significantly associated with expression of heat (silent or expressed) or with interval since calving in cows or since 12 months of age in heifers. Intracow correlation of multiple ovulations within line, system, parity and season was found to be 0.074 ($P < 0.01$). (AH g2-5)

2. The relative importance of general and specific combining ability in breeding dairy cattle. These studies were undertaken to determine the relative importance of general and specific combining ability between lines of dairy cattle within the same breed. They are designed to study the genetic methods needed for utilizing the non-additive genetic variance which may be present in the economic characteristics of dairy cattle production. Projects are cooperative with the Minnesota and Ohio Agricultural Experiment Stations and are contributing projects to the North Central Regional Dairy Cattle Breeding Project.

(a) Line development progress. At Minnesota, progress in the line development program at Rosemount was checked by recomputing the average relationship between milking age animals in the line. This relationship is now 8.1%. The Southern Experiment Station at Waseca was brought into the project by transferring some of the Rosemount animals to that station.

Eventually, about 50 milking linebred animals will be located at Waseca with a like number at Rosemount. All matings in the Rosemount-Waseca herds are to sires closely related to four descendants of Wisconsin Admiral Burke Lad. Plans are developed to increase the relationship between animals at a more rapid rate. The line development project at Morris and Crookston has proceeded as planned.

At Ohio, the line development program is progressing according to plan. Four herds are sufficiently linebred to permit between-line crossing. Two other herds are approaching the point where they can be crossed. In order to make an objective evaluation of genetic differences between lines, the frequency of alleles for blood types were evaluated for three of the lines. It is evident that lines do differ in this respect. In the A system, the frequency of the A allele was .439, .130 and .106 for the Darkmaster, BDI and Berea lines, respectively. Corresponding frequencies for the L allele in the L system were .521, .136 and .053. The frequency of occurrence of allele in 4 of the 10 antigen systems was found to be different among the lines.

(b) Inbreeding effects on production. A study was made to evaluate the low levels of inbreeding as they influence production within the line developing herds. Within-year-season, herd, sire regression analyses independent of age of Holstein cows in each of their first four lactations were derived from the data. Regression analyses for the first, second, third, and fourth lactations involved 1,233, 784, 480, and 263 within subclass degrees of freedom, respectively. The regressions of first lactation 2X, 305-day, actual milk and butterfat yields on 1% of inbreeding were -41.3 $\pm$ 9.2 and -1.24 $\pm$ 0.33 pounds, respectively. When heart girth was included in the preceding analyses as a third independent variable, the regression statistics remained the same. The regressions of second lactation milk and butterfat yields on inbreeding independent of age were -42.9 and 19.3 and -1.19 $\pm$ 0.54 pounds, respectively. For the third and fourth lactations, the regressions were within the magnitude of their standard errors of zero; for the fourth lactation they were positive. First lactation data of cows that had four lactations yielded regressions which were close to zero. These results suggest that decreasing effects of inbreeding as shown by other studies are not due to maturity of cows but rather are due to selection and culling. (AH g2-22)

3. The influence of parental relationship on the genetic merit of dairy cows and sires. This research was undertaken to determine the relative merits of line-breeding, outcrossing and crossbreeding using progeny tested bulls of high merit as service sires. Mating plans were continued for the foundation cows and for first and second generation animals in each of the various mating systems. The present herd consists of 78 outcrosses, 69 linebreds, 83 crossbred and 29 foundation females. The actual first lactation averages for the various groups are as follows: twenty-seven linebreds averaged 11,394 lb. milk, 3.94% BF., 449 lbs. BF., ave. age of 25.5 mos.; twenty-seven outcrosses averaged 10,250 lbs. milk, 4.25% BF., 436 lbs. BF., ave. age of 25.8 mos.; eight Ayrshire-Holstein crosses averaged 10,702 lbs.

milk, 4.24% BF.,454 lb. BF., ave. age of 25.3 mos.; and twelve Brown Swiss-Holstein crosses averaged 8,598 lbs. milk, 4.37% BF., 376 lb. BF., ave. age of 25.1 mos.

(a) Growth and feed efficiency among groups. Heifers from each mating system were placed on a standardized ration of free choice alfalfa hay and 3 pounds of grain per day from 12 to 16 months of age. Feed efficiency, rate of gain and hay consumption studies were made on 165 heifers. These represented the 61 outcross heifers by 6 sires, 50 linebred heifers by 5 sires; 24 A X H crosses by 2 sires; 25 S X H crosses by 2 sires, and 5 S X A H crosses by 1 sire. Analysis of variances indicated significant differences among groups and among sires within groups for therms of energy consumed in hay and average daily gain over the 120-day experimental period. The therms of energy consumed in hay were 1,154, 1,115, 1,078, 1,178 and 1,069 for outcrosses, linebreds, A X H crosses, S X H crosses and S X A X H crosses, respectively. The average daily gain (ADG) was 1.70, 1.66, 1.56, 1,72, and 1.65 for the outcrosses, linebreds, A X H crosses, S X H crosses, and S X A X H crosses, respectively. There were no differences among the groups or among sire within groups in efficiencies of feed utilization. It appears that all groups utilized the energy intake at the same relative efficiency.

The second objective of these trials was to determine if there was any relationship between total gain, rate of gain and efficiency of gain during this 120-day period and FCM yields and efficiency of FCM yield during the first lactation. To date, 74 females have completed their first lactation; 27 outcrosses by 3 sires, 24 linebreds by 3 sires; 11 A X H crosses and 12 S X H crosses by one sire each. None of the correlations were significant. The general trend in all groups except the linebreds was negative. (AH g2-24)

(b) Cow loaning program. After the Beltsville cows finish a required number of lactations, they are loaned out to cooperating dairymen in the area. The purpose of this program is to evaluate the performance of the various breeding groups in other environments. The cooperators also mate 10 of their own cows to young Beltsville bulls from each of the three breeding groups to determine the value of bulls produced by the various systems. To date, a total of 112 cows have been loaned. These cows averaged 15,085 pounds of milk, 3.98% and 601 pounds of butterfat at Beltsville. Sixty-eight cows with completed records in cooperator herds averaged 2,802 pounds of milk, 136 pounds of fat and 0.20% test less than their Beltsville records. A stablemate comparison of Beltsville cows vs. cooperator-owned cows indicated an advantage for the Beltsville cows of 168 pounds of milk and 10 pounds of butterfat. This small advantage is only partially indicative of genetic superiority. Adjustment to new environment had a depressing effect on production. (AH g2-24)

4. The use of progeny tested sires and sons of progeny tested sires.

(a) Production-longevity relationships. Production and age data on

3,879 daughters of 123 Holstein sires were used to study the relationship between first-lactation milk and milk-fat production and longevity in 79 herds. They were divided into six groups by type of ownership.

The average age at the start of the first lactation was 32.4 months, and at the start of the last complete lactation (final age) was 61.1 months. Linear regressions of final age on first-lactation production were 0.071 months/lbs. milk fat and 0.024 months/10 lbs. of milk. Corresponding correlation coefficients were 0.188 and 0.179, respectively. Differences between the owner group regression coefficients were not statistically significant. Individual sire regressions of final age on milk production varied from -0.089 + to + 0.129/10 lb. of milk and from -0.253 to +0.346/lb. milk fat. The differences between the sire regression coefficients were significant. Regression coefficients at different levels of milk production within owner groups varied widely, but differences between these regressions were statistically significant in only one group.

The regression and correlation coefficients were small but highly significant. There seems to be little doubt that on the average in these data, the higher-producing first-lactation cows had a somewhat longer productive life.

(b) Means and variances for production traits in different lactations of the same cows. The first four lactations of 1,228 cows and 1,187 of their dams were used to study the means and variances of days in milk, age at start of lactation, pounds of milk, pounds of milk fat and percent of milk fat. The differences between lactation means were significant for all five characteristics for both daughters and dams even after adjustments were made for age. The error variances in the four lactations were found to be significantly different for all five characteristics in the daughter data and for all characteristics except pounds of milk in the dam data. If more extensive studies bear out these results, then the practice of pooling production data over different lactations of the same cow could lead to erroneous interpretations.

(c) Age of calving effects on production. The influence of age at first calving and calving interval on production per day of life and total lifetime production were studied. Lifetime production records of 450 Holstein cows from the combined USDA - Utah Agricultural Experiment Station herd were used. The influence of calving interval was obtained from the records of 368 cows that had calved more than once. Cows freshening at 25 months of age had the highest production of milk and butterfat per day of life, with production per day decreasing as the age at freshening increased past 25 months. Highest total lifetime production was made by cows freshening at 30 months, followed by the freshening at 27 and 28 months of age.

A calving interval between 12 and 13 months resulted in highest production per day of life. However, cows with calving intervals between 13 and 15 months tended to stay in the herd longer and achieved a higher lifetime production. Correlations between pounds of milk produced per day of life

since two years of age and age at first freshening, calving interval, age cow left herd, percent days in production since two years of age and since first calving were -.34, -.11, .17, .50 and .24, respectively. Correlations for production of butterfat per day of life were similar. (AH g2-25)

5. Usefulness of heterosis resulting from interbreed matings. These studies are concerned with the theoretical and practical aspects of heterosis resulting from interbreed matings among dairy breeds. Projects are in progress at Beltsville and in cooperation with the Illinois and Indiana Agricultural Experiment Stations. The Beltsville study is a contributing project to the Southern Regional Dairy Cattle Breeding Project and the cooperating projects contribute to the North Central Regional Dairy Cattle Breeding Project. Most of the semen services are supplied through the cooperation of the National Association of Artificial Breeders.

(a) Genetic correlations between dairy and beef traits. Data from the Indiana project were analyzed to determine phenotypic and genetic correlations and heritability estimates for dairy and beef traits in purebred Red Danes, Milking Shorthorns and Red Polls; all possible two-breed crosses; and certain three-breed crosses. In general, the phenotypic correlations of the milk traits with feed efficiency and rate of gain were small and mostly positive. Milk and fat yield exhibited slightly negative correlations with percent lean cuts and positive correlations with carcass grade. Percent fat in the milk was correlated negatively with carcass grade and positively with percent lean cuts. None of these correlations were significantly different from zero. The genetic correlations were larger in absolute value and had the same sign as the phenotypic correlations. The confidence limits associated with them were extremely large so the genetic correlations could only be crude estimates of the true genetic correlations. However, they did indicate that some genes could be effective in both the dairy and beef traits.

Low negative correlations were found between the slaughter traits (carcass grade and percent lean cuts) and the growth traits (feed efficiency and rate of gain). Based on the phenotypic correlations from this study, selection could be made for either beef or dairy traits without serious determinable effects on the other. Also, selection for both milk and beef traits could be made simultaneously with only a slight reduction in the selection differential for each trait. (AH g2-23)

(b) Effects of crossbreeding on feed efficiency. Further analyses of feed efficiency data on Red Poll, Red Dane and Milking Shorthorn cattle and their two- and three-breed crosses in the Indiana project have been made. The purebred steers required 8.51 lb. feed/lb. gain (4.63 lbs. was in excess of maintenance requirements) and gained 2.02 lbs. daily. The two-breed crosses required 8.33 lb. feed/lb. gain (4.58 lb. above maintenance) and gained 2.10 lbs. daily. The three-breed crosses required 7.74 lb. feed/lb. gain (4.12 lb. above maintenance) and gained 2.21 lbs. daily. The major genetic effect appeared to be general combining ability or an additive genetic effect. Least squares estimates indicate the crossbreds gained faster

and more efficiently than purebreds. None of the differences were of statistical significance at the 5% level of probability although a few approached that level. However, the crossbred-purebred comparisons indicate the Red Dane-Milking Shorthorn crosses showed more evidence of heterosis than any of the other crosses. From these results, it appears the beef producing capacity of the male offspring may be enhanced to some extent by crossbreeding. (AH g2-23)

(c) Effects of crossbreeding on growth rate. In the experiment at the University of Illinois, involving crisscrossing between Guernseys and Holsteins, nine different measures of skeletal dimensions and weight were recorded at 9 different ages (from 3-60 months of age) to compare the growth rate of second generation or 3/4 bred animals to the purebred parent breeds. The means for the crosses exceeded the parental mean in 79 of the 81 cases indicating heterosis for growth rate with only 25% blood from a second breed. The differences favored the crosses to the greatest extent up through 24 months of age. The differences at later ages were small. For example, crossbreds exceeded the parental mean by an average of 4.7% in body weight up through 24 months but only 2.8% from 30 to 60 months. The 3/4 Holsteins were slightly larger than the 3/4 Guernseys but neither of the crossbred groups were as large as the purebred Holsteins. The crossbreds averaged 2 1/2% in wither height and 9% less in body weight than the Holsteins.

Preliminary data on first generation crosses among Ayrshires, Brown Swiss and Holsteins in the project at Beltsville, also indicate a small degree of heterosis for growth. The crossbreds have exceeded the expected or parental mean by 2 to 4% in body weight at 3, 6, 12, 18 and 24 months of age, and 1 to 2% in height at withers, depth of forechest, forechest girth and body length, at 6, 12 and 18 months of age. None of the crossbred groups have exceeded the growth rate of the purebred Holsteins except the Brown Swiss-Holstein crosses which were slightly heavier at 18 and 24 months of age. (AH g2-23)

(d) Effects of changes in body weight during lactation on production of purebred and crossbred cows. Body weight data on the foundation, first, second and third generation purebred Holsteins, reciprocal crossbreds and purebred Guernseys in the Illinois project were analyzed to determine the changes in body weight during the first and second lactation periods and the relationships of changes in body weight to milk and fat production. Data on 239 first and 157 second lactation animals were used in the analysis.

Partial regressions of weight on month of lactation indicated that cows of a constant age gained approximately 14.8 lb./month during first lactation and 15.0 lb./month during second lactation. The gains in the different months of lactation did not differ significantly.

The partial regressions of weight on age for a constant month of lactation indicated purebred Holsteins increased approximately 12.6 lb. for each one month in age during both first and second lactation. The corresponding

increases for Guernseys, crosses by Holstein sires and crosses by Guernsey sires were 7.8, 7.2 and 9.5, respectively.

With calving age and weight 30 days after calving held constant, the partial regressions of milk yield on gain in body weight during first lactation indicated that cows produce 10.9 lb. less milk for each one pound gain in body weight and 12.6 lb. less in second lactation. Fat yield was decreased by .41 and .48 lb. for each pound of gain during first and second lactation, respectively. Age at calving and body weight 30 days after calving were not closely associated with milk and milk fat yield during the first and second lactations. Body weight from 30 days after the beginning of first lactation to the end of the second lactation increased 23.3, 26.1, 27.4, 29.6 and 26.4% for purebred Holsteins, purebred Guernseys, crossbreds by Holstein sires, crossbreds by Guernsey sires and all breed groups combined, respectively. (AH g2-23)

(e) Effect of crossbreeding on production. Production records of purebred Red Danes, Milking Shorthorns and Red Polls; and two- and three-breed crosses from the Indiana project were analyzed for the effects of breed of dam, breed of sire, dam x sire interaction, sire in breed, year of calving season of calving, lactation number and age on milk production and persistency of milk yield. The mean milk yield of the two- and three-breed crosses was 880 and 1,550 lb. above the parental mean. The two-breed crosses were similar to the parental mean in persistency of milk yield whereas the three-breed crosses averaged 9% higher. The data indicate an increase of 10.8% in milk and 15.5% in fat production due to crossbreeding. Although the production of the crossbred groups was above the parental mean, none of the groups exceeded the pure Red Danes in total milk yield. The least squares analysis showed that within the purebreds, breed of sire, dams, breed of dam and the interaction effects were consistently significant. Whether the animal was a two- or three-breed cross influenced its performance, but the type of three-breed combination did not greatly influence production.

In the Beltsville experiment, preliminary data on two-bred crosses among Ayrshires, Brown Swiss and Holsteins indicate some increase above the "expected" (contemporary parental mean) in production traits. The Ayrshire x Holstein crosses in first lactation exceeded the parental average by 15 and 14% in milk and fat yield, respectively. The Brown Swiss x Holsteins were +17 and 16%, respectively, while the Ayrshire x Brown Swiss averaged only 10% above the expected in milk and fat. All three groups of crossbreds averaged lower in percent fat than the parental mean (range -.05 to -.11%), but all crosses averaged 10.5% above the expected in persistency of milk yield and 4.8% in gross efficiency (lbs. FCM/therm of estimated net energy consumed). The crossbreds have also averaged 3% above the expected in rate of milk flow (lbs/min). Although the performance of the crosses indicates some heterosis for production traits, none of the crossbred groups have exceeded the purebred Holsteins in rate of milking or total milk production. All crossbred groups have exceeded the Holsteins in fat percent. The Ayrshire x Holsteins have exceeded the Holsteins by 2% in fat production and

the Swiss x Holstein crosses have shown greater persistency than the purebred Holsteins. (AH g2-23)

6. Genetic methods for developing adaptability. These investigations are to evaluate the effectiveness of certain genetic methods for improving dairy cattle adaptability to hot conditions through: (a) introduction of adaptability characteristics; (b) selecting within existing breeds for further adaptability; and (c) hybridization of existing breeds by continous crossing or developing new strains from a crossbred foundation. This work is in cooperation with the Georgia, Louisiana, and Texas Agricultural Experiment Stations. All of the studies are contributing projects to the Southern Regional Dairy Cattle Breeding Project S-49. Most of the semen services are supplied through the cooperation of the National Association of Artificial Breeders. The PL-480 cooperative project in Colombia also contributes to this work.

(a) Introduction of adaptability by crossing Jerseys with Brahma cattle. Preliminary analysis of the Brahma-Jersey crossbreeding study at Texas A & M show the crossbreds have shorter lactations and average less in milk yield than contemporary paternal half-sib purebred Jerseys. The 1/2, 3/4, 7/8 and 15/16 Jersey crosses averaged 51, 24, 7 and 7% lower in milk production than the purebreds. The crossbreds also calved one month later (29 mo.) and required more services per conception (2.3) than the purebreds (1.8). One-third of the crossbreds have exceeded the average of the Jerseys in milk yield and this groups is now being mated to crossbred bulls to further determine the possibility of development of a desirable strain of cattle from combinations of these two breeds.

(b) Selection within existing breeds. Estimates for heritability of milk yield, using the intra-sire regression method on 510 daughter-dam pairs representing 36 Holstein sires in the Louisiana State University herd for the period 1927-61, were found to be .31, .38 and .40 for first lactation, second lactation and the average of all lactations, respectively. On a single record basis, the heritability for the average of all lactations was .23. The values for milk fat yield were .27, .39 and .28, respectively. Estimates obtained by the paternal half-sib correlation method on 2,243 lactations of daughters of 41 sires were somewhat inflated due to environmental trends in the herd. Repeatability estimates derived by intra-class correlations were .43 for milk yield and .40 for milk fat yield. These values represent estimates without any correction for year-season of calving. The estimates of heritability and repeatability obtained are of comparable magnitude to those for the same traits in cooler climates, thus indicating that expected changes from selection in warm climates is comparable to that of temperate climates. Also, these estimates support the contention that a fairly accurate estimate of the breeding value of a cow can be safely based on the first and/or second lactation yield. (AH g4-2)

(c) Hybridization of existing breeds by continuous crossing or developing new strains from a crossbred foundation. Lactation records made during the period 1957-62 in the herd at Reidsville, Georgia,

were analyzed to evaluate the performance of crossbreds in comparison to purebreds. The foundation females for the crossbreds were Jerseys in all cases. All the crossbred groups (1/2 Swiss-Jersey, 1/2 Holstein-Jersey, 1/2 Swiss-1/4 Holstein-1/4 Jersey and 1/2 Holstein-1/4 Swiss-1/4 Jersey) exceeded the expected (mean of parental breeds) in FCM by 11, 7, 11 and 21%, respectively. The average deviation for the 1/2 Swiss-Jersey group was 525 lb. FCM above the Jerseys and 885 lb. above the Swiss. The 1/2 Swiss-1/4 Holstein-1/4 Jersey crosses averaged 1,224, 787 and 150 lb. above the purebred Jerseys, Swiss and Holsteins, respectively. The 1/2 Holstein-Jerseys exceeded the Jerseys level by 1,048 lb. FCM, but were below the Holsteins by an average of 165 lb. FCM. The 1/2 Holstein-1/4 Swiss-1/4 Jersey group exceeded all other crossbred groups and averaged 2,113, 2,202 and 665 lb. FCM above the purebred Jerseys, Brown Swiss and Holsteins, respectively. The crossbred groups were lower in fat test than Jerseys but higher than the other purebreds. The increase in FCM yields due to crossbreeding (7-21%) are somewhat higher than reported in other studies and the first indication of crossbreds exceeding the Holsteins in total milk and fat yield. These preliminary results suggest that crossbreds are more adaptable to the conditions of Southeast Georgia than purebreds.

At the Iberia Livestock Experiment Station, Jeanerette, Louisiana, preliminary summaries on twenty 1/2 Brown Swiss and thirty-five 1/2 Holstein crosses in relation to their purebred Holstein herdmates showed the Brown Swiss crosses were far below the purebreds in milk and fat yield while the Holstein crosses were slightly below the purebreds in milk, but above in fat yield. Both crossbred groups averaged approximately 0.5% higher in butterfat and solids-not-fat test than the Holsteins. The crossbreds were also higher in persistency of milk yield. Breeding efficiency (services per conception) was high in all three groups, 1.37 for pure Holsteins and the Brown Swiss crosses, and 1.71 for the Holstein crosses. These differences were not significant. Thus far, neither of the crossbred groups has shown any advantage over the purebreds in livability (number reached calving age/number born). The average percent of those born that reached calving age was 88, 80 and 78% for Holsteins, Holstein crosses and Swiss crosses, respectively. In general, the first and second generation purebred Holsteins have exceeded the crosses in growth rate at 6, 12, 18 and 24 months of age. The Holsteins have been significantly heavier in body weight at all ages and have also tended to exceed the crossbreds in body length, and in height at withers. These preliminary results indicate that crossbreds are no more adaptable to Louisiana conditions than Holsteins sired by highly selected sires. (AH g4-2)

(d) Dairy merit of Consteno con Cuernos cattle in Colombia. A deterrent to the usefulness of the Criollo breed, Consteno con Cuernos (CCC), as a dairy animal has been failure to obtain milk let-down without the presence of the calf. At Cerete, an attempt was made to milk 142 first-fourth lactation cows without the calf present. Those milked without the calf produced less total milk yield and had shorter lactations than contemporaries milked with calf at foot. The first lactation animals did somewhat better,

however, than the older cows. Extremely high calf losses under the system of bucket feeding in open corrals were also experienced. Calf losses can be reduced by training personnel but unless some system of management can be devised for obtaining milk let-down without the calf, this may seriously impede the use of the CCC breed in a dairy operation. The 127 CCC heifers that freshened during the year averaged 2 years, 11 months of age. Indications are this can probably be reduced to at least 2 1/2 years since 96 of the animals calved at 31 months or younger. (S5-AH-1)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Genetics and Interrelationships of Performance Traits

Fowler, A. K., Ludwick, T. M., Weseli, D. F., Richardson, D. O., Brum, E. W., Rader, E. R., and Hines, H. C. 1963. Blood group segregation and possible effects on fertility in cattle. J. Dairy Sci. 46:6 p. 629, Abstract (AH gl-6).

Hines, H. C., Ludwick, T. M., Richardson, D. O., Rader, E. R., Brum, E. W., and Fowler, A. K. 1962. Effects of stage of lactation on type evaluation in first-lactation Holstein cows. J. Dairy Sci. 45:5 p. 672, Abstract (AH gl-2).

Hooven, N. W. and Plowman, R. D. 1963. Ad libitum feeding of dairy cattle. J. Dairy Sci. 46:6 p. 622, Abstract (AH gl-4).

Kiddy, C. A. 1962. The U.S.D.A. comparison tests in cattle blood grouping. Paper presented at the VIIIth Animal Blood Group Conference in Europe, Ljubljana, Yugoslavia, Aug. 21-24 (AH gl-6).

Kiddy, C. A. and Plowman, R. D. 1962. Rapid tests for protein in milk. Paper presented at the 76th Annual Meeting of the Association of Official Agricultural Chemists Oct. 15-17 (AH gl-5).

Kiddy, C. A. 1963. Do we have a good rapid protein test? Penna. Golden Guernsey News 25:4 (AH gl-5).

Kiddy, C. A., Thompson, M. P., Johnston, J. O., and Pepper, L. 1963. Genetic control of α_s and β-casein. J. Dairy Sci. 46:6 p. 626, Abstract (AH gl-5).

Plowman, R. D., Smith, J. W. and Nelson, K. E. 1963. Factors affecting flavors in milk from individual cows. J. Dairy Sci. 46:6 p. 630, Abstract (AH gl-5).

Rader, E. R., Ludwick, T. M. and Richardson, D. O. 1962. Abnormal mammary development of the young dairy heifer and its association with future performance. J. Dairy Sci. 45:11 p. 1348 (AH gl-3)

Ratcliff, L., Boyd, L. J. and Plowman, R. D. 1962. Performance and interactions of dairy sire groups on two systems of feeding. J. Animal Sci. 21:4 p. 975, Abstract (AH gl-4).

Rausch, W. H., Ludwick, T. M., Weseli, D. F., Richardson, D. O., Rader, E.R., Brum, E. W., Hines, H. C., and Fowler, A. K. 1963. The association of bovine transferrin types, as determined by disc electrophesis, with fertility and production. J. Dairy Sci. 46:6 p. 648, Abstract (AH gl-7).

Richardson, D. O., Ludwick, T. M., Rader, E. R., Hines, H. C., Fowler, A. K. and Plowman, R. D. 1963. Possibilities of early sire evaluation by the use of udder palpation information. J. Dairy Sci. 46:6 p. 628 (AH gl-3).

Thompson, M. P., Kiddy, C. A., Pepper L. and Zittle, C. A. 1962. Casein variants in the milk from individual cows. J. Dairy Sci. 45:5 p. 650 (AH gl-5).

Thompson, M. P., Kiddy, C. A., Pepper, L. and Zittle, C. A. 1962. Variations in the α casein fraction of individual cow's milk. Nature Vol. 195, No. 4845, pp. 1001-1002 (AH gl-5).

Wilk, J. C. 1962. Genetic and phenotypic relationships between certain body measurements and milk production in dairy cattle. Ph. D Thesis,

University of Minnesota (AH g1-1).

Selection and Systems of Breeding

Brandt, G. W., Brannan, C. C., Harvey, W. R. and McDowell, R. E. 1963. Crossbred dairy cattle compared to their purebred contemporaries for milk and fat production. J. Dairy Sci. 46:369, Abstract (AH g2-23).

Branton, C. 1962. Can we breed for heat tolerance? Hoard's Dairyman, 107 (11):630, 667 (AH g4-2).

Branton, C. and Evans, D. L. 1962. Heritabilities of milk yield and fat yield and genetic correlations between milk and fat yield in the LSU Holstein herd. Dept. of Dairy Sci. publication 12:72-79 (AH g4-2).

Branton, C., McDowell, R. E., Frye, J. B. Jr., and Johns, D. M. 1962. Growth and production performance on Holstein, Brown Swiss and Red Sindhi crossbred females in Louisiana and Maryland. Dept. of Dairy Sci. publication No. 12:80-82 (AH g4-2).

Branton, C., McDowell, R. E., Evans, D. L., Waters, W. H. and Frye, J. B., Jr. 1962. Breeding Holstein-Friesians for adaptability to the Gulf Coast area. Dept. of Dairy Sci. publication No. 12:61-71 (AH g4-2).

Brown, M. A. and Rinn, C. A. 1962. A summary of the artificial insemination program at Wynn State Farm, 1956-1961. Texas A & M Dept. of Dairy Sci. mimeo. (AH g4-2).

Brum, E. W. 1963. Effects of low levels of inbreeding resulting from a specific line development mating system on growth and production characteristics in dairy cattle. Ph. D Thesis Ohio State University (AH g2-22).

Brum, E. W., Ludwick, T. M., Richardson, D. O., Rader, E. R., Hines, H. C., Fowler, A. K., and Plowman, R. D. 1963. Some effects of low levels of inbreeding on production in Holstein cattle. J. Dairy Sci. 46:6 p. 619 Abstract (AH g2-22).

Clark, R. D. and Touchberry, R. W. 1962. The effect of body weight and age at calving on milking production in Holstein cows. J. Dairy Sci. 45:1500 (AH g2-23).

Gaalaas, R. F. and Plowman, R. D. 1963. Relationship between longevity and production in Holstein-Friesian cattle. J. Dairy Sci. 46:1 pp. 27-33 (AH g2-25).

Labhsetwar, A. P., Tyler, W. J. and Casida, L. E. 1962. Analysis of variation in some factors affecting multiple ovulations in Holstein cattle. J. Dairy Sci. 45:5 p. 672, Abstract (AH g2-5).

Lamb, R. C. and Kopland, D. V. 1963. Influence of age at first calving and calving interval on production per day of life and total lifetime production. J. Dairy Sci. 46:6 p. 620, Abstract (AH g2-25).

Legault, C. R. and Touchberry, R. W. 1962. The heritability of birth weight and interrelationship with production in dairy cattle. J. Dairy Sci. 45:9 (AH g2-23).

Martago, H. O. 1963. Heritability and repeatability of milk and fat yields. MS Thesis, Louisiana State University Library, Baton Rouge (AH g4-2).

Martago, H. O., Branton, C., Farthing, B. R. and Evans, K. L. 1963. First or second versus all lactation records for selecting dairy cattle in a hot climate. J. Dairy Sci. 46 (AH g4-2).

Menge, A. C., Mares, S. E., Tyler, W. J., and Casida, L. E. 1962. Variation and association among postpartum reproduction and production characteristics in Holstein-Friesian cattle. J. Dairy Sci. 45:2 p. 233-241 (AH g2-5).

Mi, M. P., Chapman, A. B. and Tyler, W. J. 1962. Genetic variation in birth weights and measurements of Holsteins. J. Animal Sci. 21:4 p. 975 Abstract (AH g2-5).

Robinson, L. K. 1963. Effects of changes in body weight during lactation on the milk and milk fat production of purebred and crossbred cows. Ph. D Thesis, University of Illinois Library (AH g2-23).

Singer, A. C. 1963. A comparison of the rate of growth of purebred and reciprocally backcrossed cattle. MS Thesis, University of Illinois Library (AH g2-23).

Starkenberg, R. T. 1963. Genetic correlations between milk and beef traits in Dual-Purpose cattle. MS Thesis, Purdue University Library (AH g2-23).

AREA NO. 6: DAIRY CATTLE - PHYSIOLOGY

Problem. Fundamental physiological research is required as a basis for improving lactational and reproductive performance of cattle. Breeding failure is a major reason for the disposal of the physiological action of hormones in controlling reproductive activity, correcting reproductive abnormalities and stimulating lactation. Research on physiological processes related to growth and development, nutritional requirements and to heat tolerance of dairy cattle is required.

USDA PROGRAM

This is a continuing program, almost entirely on basic research, conducted by physiologists and biochemists. The program is designed to elucidate the reproductive and lactational physiology of cattle utilizing physiological and biochemical techniques and to determine physiological mechanisms related to heat tolerance. The work is in progress at Beltsville, Maryland, and cooperatively at the Wisconsin, New York, Massachusetts, Texas, Louisiana, and Georgia Agricultural Experiment Stations. It is coordinated with the NE-41, W-49, and S-49 regional projects.

The Federal scientific effort devoted to the research in this area totals 7.7 professional man-years. Of this number, 2.9 are devoted to the physiology of reproduction, 2.0 to the physiology of milk secretion, 1.0 to the physiology of growth and development, 1.5 to environmental physiology, and 0.3 to program leadership.

A grant with the Veterinary School of the University of Sao Paulo, Brazil, provides for research on the anatomical and physiological characteristics affecting heat production and heat loss of Zebu, European and Zebu-European crossbred cattle and the nature and method of controlling the inheritance. Its duration is for five years, 1961-1966, and involves PL-480 funds with a $63,293 equivalent in Brazalian Cruzeiros. (Pertains to Area 5 also)

A grant with the Indian Veterinary Research Institute, Izatnagar, UP, India, supports studies on the physiology and genetics of characteristics influencing the adaptability of cattle and buffalo for dairy production. The duration of this work is five years, 1961-1965; it involves PL-480 funds with a $195,624 equivalent in Indian rupees. (Pertains to Area 5 also)

A grant was initiated this year with the Veterinary Institute, Beit Dagan, Israel, in the Department of Reproduction, for work on a project entitled "Comparative Studies of Repeat Breeders and Normal Cows and Heifers." It is for a five-year period and involves PL-480 funds to the extent of $124,600 equivalent in Israeli pounds.

A grant was initiated with PL-480 funds with the Department of Applied Pharmacology, The Hebrew University, Rehovoth, Israel, on the mechanism of lactation and its augmentation by hypothalamic stimulation. It is supported for five years and is for $126,767 equivalent in Israeli pounds.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

A large portion of this work is reported in Area 1, Animal Biology, because it has application to classes of livestock other than dairy.

1. The corpus luteum

(a) The role of progesterone in maintenance of the corpus luteum of the estrual cycle. The role of progesterone in luteal maintenance during the ovine estrual cycle was studied by comparing spontaneously formed corpora lutea with corpora induced experimentally by injection of gonadotropin. Corpora lutea formed spontaneously after removal of natural corpora functioned for the length of a normal cycle from the time they were formed. Experimental corpora lutea induced on days 5, 7, or 9 of the estrual cycle, while natural ones were present, became functional, but did not modify the cycle length. When progesterone was given from days 4 to 7 and natural corpora lutea were removed on day 5, corpora induced on day 7 also became functional and did not modify the cycle length.

In other experiments progesterone was given from days 11 through 22 and induced corpora were formed on day 21. These induced glands usually failed to show any evidence of function or of being maintained. Estrogen treatment, electrical stimulation (per rectum), or both, given while the induced corpora lutea were being formed, failed to establish maintenance of these glands.

(b) Progesterone content of corpora lutea and ovarian effluent blood. Progesterone levels in corpora lutea were studied at 4, 6, 8, 10, 12 and 14 days after estrus in 38 normal ewes. The average weight and total progesterone content of corpora lutea were affected by stage of the cycle ($P < .01$).

Relationships also were determined between hormone content of corpora lutea and ovarian effluent blood plasma progesterone at 6, 10, and 14 days of the cycle in normal and superovulated ewes. The total luteal weights of superovulated ewes decreased significantly from day 6 to 14 after ovulation. Blood flow rate in these ewes at the same stage of the cycle was correlated with total luteal weight (0.56, $P < .01$). The secretory rate (amount of progesterone in effluent plasma/unit time) was significantly correlated with the luteal progesterone content ($P < .05$).

The data support the hypothesis that luteal progesterone content is indicative of the level of function of this gland in terms of the amount of hormone released into the blood.

(c) Effects of experimental endocrine treatment of animals upon the activity of their corpora lutea. Attempts have been made to modify corpus luteum size and activity with several hormonal substances which may be involved in the function and maintenance of this gland. Progestogen levels in the gland and the amounts of these steroids produced in vitro during incubation of luteal tissue have been used as measures of luteal activity.

(1) Oxytocin. Control CL (day 14) and CL obtained on day 14 of a cycle after oxytocin treatment on days 12 and 13 showed little differences in weight, initial progesterone content or progesterone content after in vitro incubation with ATP, DPN, and pregnenolone.

In another series of experiments the progesterone level was measured on the 11th day of the cycle in Holstein heifers treated daily with oxytocin or with daily oxytocin injections plus daily injections of the anterior pituitary preparation being tested for its ability to overcome the inhibitory effects of oxytocin on the corpus luteum. Oxytocin treatment reduced the mean total progesterone level from 262 µg in control CL to 30 µg.

Prolactin, somatotrophin and equine LH were not luteotrophic in the bovine, since they failed to overcome oxytocin induced inhibition of luteal development and progesterone production. On the other hand, HCG and a crude bovine anterior pituitary extract were strongly luteotrophic and resulted in an increase in mean total progesterone.

Histologically, the new corpora lutea formed during oxytocin treatment closely resembled normal corpora lutea collected from untreated cattle at 2-3 days post-estrum. The progesterone content of these new corpora lutea from oxytocin treated heifers was also quite similar to that found in normal corpora lutea of a similar age. These observations suggest that the inhibitory effect of oxytocin on luteal development and progesterone production does not become effective until the third day after estrus.

(2) Luteinizing hormone (LH). Growth of normal corpora lutea was most rapid during the 8 days following ovulation. Day 6, 8, and 10 CL removed from rabbits treated with a single intravenous injection of LH 48 hours previously were significantly smaller than CL of a comparable stage of growth. Day 6 LH treated CL were retarded in growth, day 8 CL exhibited luteostasis (no change in weight) and day 10 CL had regressed. LH injected into 9 day pseudopregnant rabbits caused regression of natural CL but, at the same time, induced the formation of new CL. These induced CL continued to grow and did not regress at day 16-17 of that cycle, thus indicating that the natural mechanism by which the life span of natural corpora lutea is terminated had no effect on the ability of the induced corpora lutea to reach maturity. (AH h5-6, cooperative with the University of Wisconsin).

2. The anterior pituitary-ovarian interrelationship in experimental endocrine states. The ripening of an ovarian follicle and the process of ovulation is dependent upon the secretions of the anterior pituitary gland. The relationship of the resultant corpus luteum to the anterior pituitary was studied by determining the relative content of follicular stimulating hormone (FSH) in the pituitary after progesterone treatment. Progesterone treatment from day 7 of the cycle to day 41 depressed both the size of the follicles and the total follicular fluid weight. FSH and luteinizing hormones (LH) concentrations were not affected by progesterone administration. The injection of oxytocin from the day of heat to day 6 of the cycle produced a smaller CL and a reduced progesterone content but had no effect on hypophyseal FSH and LH.

The pituitary-ovarian relationship was also studied during the perinatal period. CL from a group of cows slaughtered at 20 days pre-partum showed 26 μg progesterone per gram of CL tissue. CL from the day of calving had no detectable progesterone. Preliminary analysis of pituitary assay data showed that the pre-partum and day of calving groups had comparatively more FSH and less LH than did the 21 day post-partum group. (AH h5-6, cooperative with the University of Wisconsin).

3. Hypothalamus-pituitary-corpus luteum interrelationships. Experiments utilizing renal autografts of anterior pituitary glands were designed to determine how the hypothalamus and higher nerve centers influence pituitary gonadotrophin secretion and ovarian activities. These rats bearing renal autografts of anterior pituitary glands provided an in vivo system for studying the effects of various hypothalamic substances on the isolated pituitary. Corpora lutea were maintained for prolonged periods of time in the autografted rats, as had been previously reported, while corpora from hypophysectomized rats were less well maintained.

Homogenates of bovine hypothalamic tissue, oxytocin and vasopressin all caused nearly complete gross and histological regression of corpora lutea. The results suggest that the hypothalamic homogenate and the oxytocin and vasopressin preparations used all contained substances capable of stimulating the transplanted pituitary gland to produce a luteolytic hormone. In another experiment conducted the same way, the uteri were traumatized to determine whether decidual cell reactions would be induced. Deciduomata formed in 68 percent of the untreated rats bearing autografts, proving that the corpora lutea in these animals continued to secrete progesterone.

The findings that injections of bovine hypothalamic extracts and vasopressin cause regression of the corpus luteum in the rat under several experimental conditions are of considerable theoretical interest, and may eventually contribute to an understanding of how the hypothalamus influences the release of anterior pituitary hormones. (AH h5-3 Cooperative with Cornell University).

4. Experimental alteration of the estrous cycle in cattle. This work is part of a study to determine the factors which control ovulation and regulate the estrous cycle in cattle. Two commercial orally active progestational compounds, Provera and Lutinyl (CAP), were fed to Holstein heifers to regulate the estrous cycle. Provera was fed to 19 Holstein heifers for 14 days. All heifers came in estrus 2-6 days after the hormone was withdrawn and 9 (49%) of them conceived when bred at this time. This treatment appears to be less desirable than those previously reported, since the heifers came in estrus over a slightly longer period of time, and the fertility was slightly lower.

Major interest during the year has centered around a highly active chlorinated progestin, Lutinyl or CAP. The following conclusions are drawn from these experiments: (1) This compound effectively inhibits estrus in Holstein heifers and cows when fed at rates as low as 12 mg. per day. (2) Fairly good synchronization of estrus is obtained within a 3-day period after the hormone is withdrawn. (3) The conception rates of the cattle bred at the artificially controlled estrus vary from 50 to 60 percent. (4) Subsequent cycle lengths are normal and indications are that normal conception rates (60-70%) are obtained in heifers bred at the first subsequent estrus. This compound appears to be potentially useful for estrous cycle synchronization in dairy cattle and its potency may make its use economically feasible.

A review of all of the cycle synchronization trials conducted to date suggests that animals are slower to come in estrus and less well synchronized when the hormone is fed mixed with the entire daily grain ration than when it is fed individually in small amounts of concentrate. The finding that fairly good synchronization and fertility can be obtained with a total of only 216 mg. of hormone per animal suggests that cycle synchronization may become practical from an economical standpoint.

Administration of oxytocin on days 3 through 6 of the estrous cycle was effective in shortening the length of the cycle. Simultaneous administration of epinephrine (8 mg daily) or atropine (50 mg daily) prevented this action. Epinephrine alone on these days has no effect on cycle length; the effect of atropine given alone is currently under study. (AH h5-3, Cooperative with Cornell University and AH h5-4 Cooperative with the University of Massachusetts)

5. Sperm transport through the tubo-uterine junction. Studies were initiated to determine spermatozoan transport through the tubo-uterine junction of rats and cattle. Immotile rat, rabbit, bull and human spermatozoa when introduced into the tubo-uterine junction did not appear to select against the passage of foreign sperm, nor was motility essential for transport.

Sperm transport has also been studied in the immature bovine. Motile bull sperm were found in the oviducts of young calves (29-128 days of age) within 13 minutes (the earliest time studied) after vaginal deposition. No difference in transport time was found between hormonally treated (various combinations of PMS, HCG, progesterone and estrogen) and untreated animals.

Leucocyte invasion of the vagina was noted in these calves. In a further study of this phenomenon, maximum influx was found to occur between 4 and 8 hours after vaginal insemination. Bacteria-free semen was capable of initiating this response, while introduction of the diluent or sterile physiological saline was ineffective.

Secretory activity of the oviduct is being studied by means of a collecting device attached to the flank of the animal and connected to the oviduct by a polyethylene catheter. In sheep a maximum secretion rate of 0.085 ml/hr. occurs at estrus, with a minimal rate of 0.010 ml/hr. at mid-cycle. Collected secretions are being analyzed for quantitative changes associated with the cycle. Similar procedures are being applied to cattle, and it is the further hope that the influence of these secretions on sperm and ovum viability and metabolism can be determined. (AH h5-4, Cooperative with the University of Massachusetts).

B. Physiology of Milk Secretion

1. The histamine concentration in the milk, blood and urine of dairy cattle. The histamine levels in milk, blood and urine have been determined as part of studies on the role of histamine in secretory and other processes in dairy cattle. Blood histamine values in 19 growing Holstein heifers, from birth to 45 weeks, averaged 0.3 µg/ml. Eight bulls showed similar blood values of 0.3 µg/ml. Blood levels during this rapid growth period showed little change, values being slightly lower during the earlier weeks. Blood histamine concentration of 5 animals sampled at 6 hour intervals for 3 days indicated little diurnal variation. Such repetitive sampling was, however, associated with a progressive increase in histamine level. Twenty-five milk samples from 15 cows were analyzed for histamine, the mean concentration being 0.5 µg/ml. When the fluorimetric histamine procedure was applied to urine, 4 samples from heifers fed alfalfa-grass hay showed a mean concentration 1.1 µg/ml while 4 samples from animals fed alfalfa-grass silage were 19.5 µg/ml. These concentrations averaged about 20 to 30 times those found in blood. Computed daily urinary excretion was 2-12 mg and 48-356 mg respectively for the hay and silage fed animals. (AH h5-1)

2. The mechanism of lactation and its augmentation by hypothalamic stimulation. The interrelationship of the hypothalamus and the anterior pituitary gland in stimulation and maintenance of lactation was studied by depressing the activity of the hypothalamus with tranquilizers and other drugs. Reserpine, nine phenothiazine derivatives and five tranquilizers and Librium were studied for their mammotropic and lactogenic effects. In adequate doses, reserpine was found to induce lactation along with morphological and histological changes in the ovaries and uteri similar to those encountered in lactating rats. In pseudopregnant rabbits reserpine caused continued lactation.

In an initial screening of the 16 drugs perpherazine was found to be most effective and accordingly, further studies will be concentrated upon this

compound. Rats and rabbits treated with perphenazine for 1 week reacted with copious milk secretion. Preliminary results indicate that this lactation is due to a prolactin-releasing factor of the hypothalamus, since extracts of such hypothalami produce lactation in rats. (A10 - AH-3 - Israel)

C. Physiology of Growth and Development

The effects of nutrition during early growth and development on reproductive performance. The studies of reproductive performance of cattle fed Low, Medium and High levels of nutrients during early life have continued. Of the 34 cows fed Low, Medium, and High levels of nutrients during early life, only 9, 4, and 4, respectively, remain in the herd. The numbers of cows that have become sterile are: Low, 0: Medium, 4: and High, 8. No difference in milk yield in any of the first four lactation periods has been observed between any two of the early-life treatment groups. However, the output of milk per unit of metabolic size has been somewhat lower for the High cows than for the other two groups, in all lactations.

The most important observations made to date are as follows: (1) Heifers smaller than normal at the time of first calving reach normal size by the time of the third calving when fed liberally after the first calving. (2) Cows, while calving, have produced at least as much milk through the sixth lactation as cows which were fed liberally throughout. (3) When heifers are not bred earlier than 18 mos. of age, high-level, early-life feeding is impractical. (4) Based upon the production response through the sixth-lactation period, heifers can be raised quite satisfactorily on as little as 150 lbs. of milk (with limited amounts of dry concentrates) and an all-roughage ration after 6 mos. of age. (5) Low levels of nutrients early in life retard sexual maturity. (6) The level of feeding early in life did not affect the rate of conception for the first pregnancy. (AH h5-3 Cooperative with Cornell University).

D. Environmental Physiology

These studies deal with the determination of the anatomical and physiological characteristics affecting heat production and heat loss of dairy cattle under hot conditions and the nature of the inheritance of these characteristics. Work is in progress at Beltsville and in cooperation with the Georgia and Louisiana Agricultural Experiment Stations. These studies contribute to the Southern Regional Dairy Cattle Breeding Project, S-49. Cooperative projects sponsored under PL-480 grants in Brazil and India also support this work.

1. Methods of determining thyroid functions of animals under heat stress. Studies were conducted at Louisiana State University to evaluate the accuracy and repeatability of five methods for determining thyroid functions. The methods compared were thyroid secretion rate (substitution), thyroid utilization rate, estimated thyroxine secretion rate, serum protein bound iodine (PBI) and metabolic heat production. All the methods

were evaluated under cool conditions (60-70°F.) and at 90°F. The results indicate the most desirable method for determining thyroid function under heat stress was thyroxine secretion rate (substitution) method. Thyroxine utilization rate was found to have a non-significant positive correlation with both the thyroxine secretion rate (substitution) and metabolic heat production methods and a negative correlation with PBI. Estimated thyroxine secretion rate and metabolic heat production were found to have a significant positive correlation of .79 under both temperature conditions and, where accurate PBI data were available, could be used to determine thyroid function. Metabolic heat production may be used under uniform cool conditions to determine thyroid function, but was found to be unreliable when animals were under heat stress. PBI did not appear to be an accurate measure of thyroid function under either the cool or hot conditions. (AH g4-1)

2. Effect of photoperiod, temperature and humidity on the semen production of dairy bulls. A study was made at Louisiana State University to determine the effect of daily photoperiod and temperature on fertility of dairy bulls from May-October. Three groups were used; one kept in a barn under prevailing daylight and temperature conditions; the second in the same barn with the daylight increased gradually at 7-day intervals from 14 to 16 hours; and a third group was kept in a climatic control chamber at 64°F. with the length of the daylight period increasing from 14 to 16 hours. The percentage of shipable ejaculates was used to evaluate the treatments. The group under the regular barn conditions averaged only 18.3% shipable ejaculates while the increased photoperiod group averaged 32.6%, and those kept at 64°F. averaged 75.5%. These tests indicate that both length of photoperiod and temperature are factors in the production of good quality semen by dairy bulls during the summer months. (AH g4-1)

3. Some physiological responses of Indian cattle and buffaloes to heat stress. Studies of the responses of various breeds of cattle and buffalo are being conducted at the Indian Veterinary Institute, Izatamagar, India, under a PL-480 grant. Groups of yearling heifers represented the Hariana, Kankrej and Tharparkar breeds of cattle and Murrah buffalo have been subjected to cool conditions (70°F.) and 6-hour periods of hot-dry (120°F. dry bulb with 15% relative humidity) and hot-humid (105°F. dry bulb and 70% humidity) conditions in a psychrometric chamber. Exposure to both the hot-dry and hot-humid conditions resulted in significant changes over the cool conditions but the responses of the three breeds of cattle were very similar. The degree of response in the buffalo differed, however, from the cattle in several respects.

In the cattle, both skin temperature and coat radiations showed significant rises under the hot conditions with the responses under the dry and humid conditions being similar. Under the high temperatures there were declines in hematocrit and hemoglobin with the greatest decline under the humid conditions. There was also a significant decrease in erythrocyte counts under the hot conditions. Under the hot-humid conditions significant drops in calcium and inorganic phosphorus were observed whereas under the hot-dry

atmosphere the calcium and phosphorus levels increased. A rise in blood glucose occurred at the high temperatures with somewhat higher levels under the humid conditions. Blood and plasma volume showed significant increases at the high temperature.

From the studies thus far, the most significant factors in behavior of these Zebu breeds as compared to results reported for European breeds have been an increased pulse rate with exposure to hot conditions and higher rates of sweating, but more data will be needed for verification. Data on skin temperature, rectal temperature and blood constituents are within the limits reported for European breeds.

The rectal temperature of the Murrah buffalo heifers was somewhat lower than for cattle under the cool conditions but under the test conditions the buffalo had higher rectal temperatures. There was a marked difference in the respiration rates of buffaloes and cattle upon exposure to the hot conditions with the buffaloes having the higher rates. Buffaloes showed a lower pulse rate under cool conditions and the change in rate with exposure to hot conditions was of a much lower magnitude than in cattle. Respiratory minute volume of the buffalo was appreciably lower under cool conditions but significantly higher than for cattle under the hot-humid and hot-dry conditions. The differences in response of the two species in respiratory minute volume seems related to differences in respiratory rate. The skin temperature of the Murrah heifers increased about the same as that for cattle under the hot conditions. The changes in hematocrit, hemoglobin and blood glucose followed similar patterns to that of the cattle with the buffalo values being somewhat lower. (A7 AH-1)

4. Adaptability studies in Brazil. The adaptability of European breeds (Brown Swiss, Holsteins, and Jerseys); Zebu breeds (Nellore and Kankrej); and crosses of European and Zebu, to conditions in Southern Brazil is being studied at the Instituto de Zootecnia at Pirassununga, Brazil.

(a) Reproduction of Jersey cattle. Studies on the reproductive performance of Jerseys, two or more generations away from importation, indicate that breeding efficiency compares favorably with that reported for temperate areas. The average services for conception, over all gestations, was 1.54. The average age of first conception was 19 months, and the mean age at first calving was 29 months, but the interval from calving to conception in second and later gestations was longer than desired (113 days) due to silent heats or no ovulation. The delayed breeding resulted in a calving interval of slightly over 14 months. The average gestation period (274 $\pm$ 1.05 days) was somewhat less than reported for Jerseys in temperate climates. The workers are of the opinion that conditions of climate in Brazil are not severe enough to interfere with sexual maturity, but a combination of climate and nutrition are probable factors in delaying conception during lactation.

(b) Hair coat characteristics. Development of a very short hair coat seems to be one of the adjustments European breeds make when introduced into tropical or sub-tropical areas. A study of the hair coat depth of imported Brown Swiss versus those reared in Sao Paulo state for two generations indicated the imported animals had shorter hair coats after one year but not as short as those born in Brazil. The mean hair coat depth for the imported stocks was 0.55 inches during winter and 0.24 inches in summer, whereas the means for the local reared animals were 0.21 and 0.11 inches. Brazil reared Holsteins and Jerseys also had very short coats but not as short as for the pure Zebus which were too short to measure. Crosses of 1/2, 3/4 and 7/8ths Holstein-Zebu breeding by imported Holstein bulls had hair coats similar to that of second and later generation Brazil Holsteins. Results to date indicate both genetic and environmental influences are involved in hair coat depth. Further, it appears that the time lapse for imported cattle to develop a short hair coat has a direct relation to their survival and performance in Brazil. (S3-AH-7)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Physiology of Reproduction

Black, D. L., Davis, J. 1962. A blocking mechanism in the cow oviduct. J. Reprod. and Fertil. 4:21-26 (AH h5-4).

Black, D. L., Duby, R. T. and Riesen, J. 1963. Apparatus for the continuous collection of sheep oviduct fluid. J. Reprod. and Fertil., in press (AH h5-4).

Brunner, M. A., Hansel, William, and Hogue, D. E. 1963. Use of 6-methyl-17-acetoxyprogesterone (MAP) and pregnant mare serum to control estrus in cycling and anestrous ewes. J. Animal Sci., in press (AH h5-3).

Casida, L. E. 1961. Present status of the repeat-breeder cow problem. J. Dairy Sci. 44:2323 (AH h5-6).

Collins, W. E., Inskeep, E. K., Dreher, W. H., Tyler, W. J., and Casida, L. E. 1962. Effect of age on fertility of bulls in artificial insemination. J. Dairy Sci. 45:1015 (AH h5-6).

Collins, W. E., Inskeep, E. K., Tyler, W. J., and Casida, L. E. 1962. Variation in conception rates of Guernsey cattle. J. Dairy Sci. 45:1234 (AH h5-6).

Faulkner, L. C. 1962. Hypothalamic substances in adenohypophyseal function. Ph.D. thesis. Cornell University, Ithaca, New York (AH h5-3).

Faulkner, L. C. and Hansel, W. 1962. Hypothalamic substances in adenohypophyseal function. The Physiologist, 5:138, Abstract (AH h5-3).

Hansel, W. Artificial estrous cycle regulation in ruminants. 1962. Proc. Eleventh Animal Feed Symposium, American Cyanamid Co., Princeton, N. J. April 16-18, 1962 (AH h5-3).

Hansel, W., VanBlake, H., and Malven, P. V. 1962. Artificial estrous cycle synchronization in cattle by feeding techniques. Proc. Cornell Nutrition Conference for Feed Manufacturers, 1962, pp. 67-76 (AH h5-3).

Hansel, W. Controlled estrus in cattle. Proc. Fifteenth Annual Convention of the National Association of Artificial Breeders, Cedar Rapids, Iowa, August 19-22, 1962, pp. 167-178 (AH h5-3).

Hawk, H. W., Turner, G. D., Brinsfield, T. H., Whitmore, G. E., and Norcross, M. A. 1963. Embryo survival in first-service and repeat breeder cattle after ovariectomy and hormone therapy. J. Dairy Sci. 46:641, Abstract (AH h5-8).

Howe, G. R., and Black, D. L. 1963. Migration of rat and foreign spermatozoa through the utero-tubal junction of the oestrous rat. J. Reprod. and Fertil. 5:95-100 (AH h5-4).

Howe, G. R., and Black, D. L. 1963. Spermatozoan transport and leucocytic responses in the reproductive tract of calves. J. Reprod. and Fertil., in press (AH h5-4).

Howe, G. R., Black, D. L., Foley, R. C., and Black, W. G. 1962. Ovarian activity in prepuberal dairy calves. J. Anim. Sci. 21:82-90 (AH h5-4).

Inskeep, E. K., Oloufa, M. M., Pope, A. L., and Casida, L. E. 1963. Functional capabilities of experimentally induced corpora lutea in ewes. J. Animal Sci. 22:159 (AH h5-6).

Labhsetwar, A. P., Tyler, W. J., and Casida, L. E. 1962. Analysis of variation in some factors affecting multiple ovulations in Holstein cattle. J. Dairy Sci. 45:672, Abstract (AH h5-6).

Malven, P. V. and Hansel, W. 1962. Effects of endometrial extracts, vasopressin and oxytocin on luteal function in rats. J. Dairy Sci. 45:681, Abstract (AH h5-3).

Mares, S. E., Zimbelman, R. G., and Casida, L. E. 1962. Variation in progesterone content of the bovine corpus luteum of the estrual cycle. J. Animal Sci. 21:266 (AH h5-6).

Mares, S. E. and Casida, L. E. 1963. Effect of exogenous oxytocin in the progestogen content of the bovine corpus luteum. Endocrinol. 72:78 (AH h5-6).

Menge, A. C., Mares, S. E., Tyler, W. J., and Casida, L. E. 1962. Variation and association among postpartum reproduction and production characteristics in Holstein-Fresian cattle. J. Dairy Sci. 45:233 (AH h5-6).

Simmons, K. R. 1962. Nature of the luteotrophic hormone in the bovine. Ph.D. thesis. Cornell University, Ithaca, New York (AH h5-3).

Simmons, K. R. and Hansel, W. 1962. Nature of the luteotrophic hormone in the bovine. J. Animal Sci. 21:1029, Abstract (AH h5-3).

VanBlake, H., Brunner, M. A. and Hansel, W. Further studies on estrous cycle synchronization in cattle. Proc. Eastern Division American Dairy Science Association. Orono, Maine. August 14-15, 1962, Abstract (AH h5-3).

VanBlake, Henry, Brunner, M. A., and Hansel, W. 1963. Use of 6-chloro-Δ^6-dehydro-17-acetoxyprogesterone (CAP) in estrous cycle synchronization of dairy cattle. J. Dairy Sci. 46:459-462 (AH h5-3).

Physiology of Milk Secretion

Wrenn, T. R., Bitman, Joel, Cecil, Helene C., Connolly, Mary R., Gilliam, D. R., Kiddy, C. A., and Schultze, W. D. 1963. Some blood histamine values of parturient cows and young calves. J. Dairy Sci. 46:479-480 (AH h5-1).

Physiology of Growth and Development

Bitman, J., Cecil, H. C., Connolly, M. R., Miller, R. W., Okamoto, M., Thomas, J. W. and Wrenn, T. R. 1962. Influx of sodium thiocyanate into cerebrospinal fluid in normal and vitamin A deficient calves. J. Dairy Sci. 45:872-878 (AH h1-3).

Bitman, J., Cecil, H. C., Connolly, M. R., Miller, R. W., Okamoto, M., and Wrenn, T. R. 1962. Effect of vitamin A deficiency on efflux of sodium thiocyanate from cerebrospinal fluid. J. Dairy Sci. 45:879-881 (AH h1-3).

Okamoto, M., Bitman, J., Cecil, H. C., Connolly, M. R., Miller, R. W., and Wrenn, T. R. 1962. Replacement and absorption of cerebrospinal fluid in normal and vitamin A deficient calves. J. Dairy Sci. 45:882-885 (AH h1-3).

Reid, J. T., Loosli, J. K., Trimberger, G. W., Turk, K. L., Asdell, S. A. and Smith, S. E. 1963. The effect of plane of nutrition during early life on growth, reproduction, production, health and longevity of Holstein cows. I. Birth to fifth calving. Cornell Univ. Exp. Sta. Bull., in press (AH h5-3).

Wrenn, T. R., Bitman, J., Cecil, H. C., and Gilliam, D. R. 1963. Histamine values in dairy cattle. J. Dairy Sci. 46:634, Abstract (AH h5-1).

Environmental Physiology

Guidry, A. J. and Stone, H. A. 1962. A comparison of various methods used to determine thyroid functions in Louisiana. Dept. of Dairy Sci. Publication No. 12:109-111 (AH g4-1).

Johnston, J. E., Naelappa, H., and Frye, Jr., J. B. 1963. Physiological responses of Holstein, Brown Swiss and Red Sindhi crossbred bulls exposed to high temperatures and humidities. J. Animal Sci. 22:432 (AH g4-1).

Roussel, J. D., Patrick, T. E., Kellgren, H. C. and Shelwick, J. O. 1962. Effect of artificial light, temperature and humidity on the physiological responses of dairy bulls. J. Dairy Sci. 45:669 (AH g4-1).

Thompson, R. D., Johnson, J. E., Breidenstein, C. P., Guidry, A. J. and Burnett, W. T. 1962. Effect of thermal conditions on adrenocortical, thyroidal and metabolic response of dairy heifers. J. Dairy Sci. 45:669 (AH g4-1).

Weldy, J. R. and McDowell, R. E. 1962. Evaporative losses of Holstein cows at 70 and 90°F. J. Animal Sci. 21:1031 (AH g4-1).

Weldy, J. R., McDowell, R. E., and Van Soest, P. J. 1962. The influence of heat stress on rumen VFA levels. J. Animal Sci. 21:1031 (AH g4-1).

AREA NO. 7: DAIRY CATTLE - NUTRITION AND MANAGEMENT

Problem. Information on the nutritional processes and requirements of dairy cattle is needed to obtain a more precise evaluation of feeds and rations as a basis for improving feeding practices on farms. Shifts in sources of nutrients fed to dairy cattle require studies on the optimum combination and specific supplements needed in order to provide for the most profitable production. Also, dairymen need to reduce costs including man-hours of labor and develop better management in the use of improved types of dairy equipment and feeding, bedding, and milk handling systems.

USDA PROGRAM

The current program is conducted by biochemists, nutritionists and dairy husbandmen. At Beltsville, studies are in progress on the factors which contribute to the heat production and maintenance requirements of grazing animals; the relationship between net energy, metabolizable energy, and total digestible nutrient values in dry roughages, silages, green roughages, and concentrates; and the relationship between digestibility and the chemical composition and solubility of various feed constituents. Calorimetric techniques are being applied to studies on the effects of dietary and physiological factors on energy metabolism and requirements of cattle. A cooperative project at Tifton, Georgia, has been recently initiated on the residues in milk resulting from the ingestion of pesticides and herbicides associated with the treatment of animals and crops.

At Beltsville, Maryland, research is being conducted on the effects of crop maturity, moisture content, preservatives, including methods of handling and conditions of storage, on the chemical quality, palatability and feeding value of silages. In conjunction with this effort, biochemical studies are being made to determine the effect of the composition of forage at the time of ensiling and of varying imposed conditions on the composition of the resulting silage. Related to the Beltsville studies is cooperative work at Lewisburg, Tennessee; Willard, North Carolina; and Puyallup, Washington. The objective of the work at the Tennessee station is to determine the effectiveness of various practical ensiling procedures by varying such factors as moisture, preservatives, type of silo, etc. At North Carolina, comparisons are being made of upright and bunker type silos. At Washington, the scientists are studying comparisons of bunker and tower silos. Pasture studies at Beltsville, Maryland, involve the effect of varying stocking rates on nutrient yields per acre and on production per animal. In cooperation with the Washington State Experiment Station at Puyallup, Washington, work is being carried out to determine dry matter consumption and digestibility of nutrients from pasture species.

A cooperative project at Logan, Utah, has been undertaken to measure the variations in efficiency of forage utilization by dairy heifers and to determine the factors which account for these variations.

At Beltsville, Maryland, a continuing study is underway to obtain information on the extent of the variation in amount of dry matter and total digestible nutrients the dry, non-pregnant, mature cow requires to maintain body weight under practical conditions and to study and evaluate various factors that may influence the maintenance requirements.

The work at Beltsville, Maryland, also consists of studies on wilted silage as a forage for growing dairy heifers, the vitamin and mineral requirements of calves and deficiency symptoms using a synthetic type of diet with particular emphasis on vitamin A and magnesium deficiency. At Willard, North Carolina, the research involves pasture utilization by young, growing cattle.

Scientists at Beltsville are engaged in studies on the environmental conditions and the mechanisms of infection involved in bovine mastitis. They are also making a comparison of hand vs. machine milking of dairy cattle. In cooperation with Agricultural Engineering, Entomology, and Eastern Utilization, research is in progress on electrically-controlled and operated equipment for reduction of labor in dairy cattle management; on the evaluation and development of physical methods for control of flies and other dairy cattle pests; and on the relationship between management practices and milk quality including flavors.

Cooperative work with Agricultural Engineering and with the Georgia Coastal Plain Experiment Station is being conducted on the influence of management practices and other environmental factors on the adaptability of cattle to the Southeastern United States.

The Federal scientific effort devoted to research in this area totals 25.4 professional man-years. Of these 7.0 are in digestion and metabolism, 8.1 in forages, 3.1 in nutritional requirements, 3.6 in calf feeding, 2.7 in management practices, and 0.9 in program leadership.

A grant with the Government Agricultural College and Research Institute, Ludhiana which is affiliated with Punjab University, Chandigarh, Punjab, India, provides for research on factors affecting the utilization of low-grade roughages and production of volatile fatty acids in the rumen of cattle. Its duration is for five years, 1962-67, and involves PL-480 funds with a grant of $86,598 equivalent in rupees. (Pertains to Area 1 also).

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

The question concerning the most accurate method of evaluating and expressing the energy values of feeds has not been settled. Some use total digestible nutrients while others have suggested that metabolizable energy or net energy are more suitable for evaluating feeds. There is also the question of supplementary effects between feeds (i.e. forages and concentrates) as well as the question of efficiency of utilization of energy for the various productive uses such as fattening, growth, or lactation. The energy laboratory was established to answer these questions and research is in progress on each of the above problems. The influence of dietary factors on the utilization of energy for lactation is being studied and a considerable amount of data has been collected during the past year.

1. Development of computer programs for energy balance trials. The routine calculations associated with energy balance trials are extensive and of a repetitive nature. The time required to perform these computations forms an important portion of the total labor involved in energy metabolism experiments, so computer programs were developed to automatically decode, calculate, and summarize data. These programs should prove useful not only to increase the speed, reliability, and ease of subsequent summarization and statistical treatment of the data collected in the USDA Energy Metabolism Laboratory, but should also be helpful to other investigations in which digestion and balance trials are conducted. A considerable amount of time has been spent in developing the computer programs, since over 400 individual equations were developed and programmed to decode automatically recorded data, calculate respiratory exchange, combine feed, orts, feces, milk, and related data and summarize the carbon, nitrogen, and energy balance experiments. Other research programs in which only digestion trials or nitrogen balance experiments are conducted can use a portion of one of the programs for computations and summaries.

Three programs are now being used. The first, program "A", is used to decode, calculate, and summarize the gas volumes and respiration chamber conditions. During a respiration trial, 240 cards per animal per day are punched automatically. These are processed at the rate of 175 cards per minute, or 1.33 minutes per animal per day. The "B" program is then used to combine the gas composition and related information with the corrected gas volume, and to compute the oxygen consumption, carbon dioxide, and methane production, gaseous carbon excreted, total heat production and other information. Since July 1962 these two programs have been used regularly, with the results being obtained on the same day the respiration trial ended.

The third program, "C", was prepared to combine all the data collected during carbon-nitrogen-energy balance studies and to compute digestion coefficients, utilization of carbon, nitrogen, and energy, maintenance requirements of the animals, distribution of losses of carbon, nitrogen, and energy, the metabolizable energy of the rations, energy balance, net energy, and various other information. If respiration data is not available this program may be used to summarize digestion trials and nitrogen balance experiments.

With the completion of these programs, it is now possible to compute and summarize energy balance trials in only 30 minutes, as compared to the three months required formerly to perform these computations manually. (AH h2-8)

2. Fasting metabolism of dry non-pregnant cows. The fasting metabolism of the adult ruminant has been the subject of investigations by physiologists and nutrition workers for over a century. The fasting (basal) metabolism has been used extensively for computing the effects of muscular work, lactation, gestation, maintenance, temperature regulation, growth, and specific nutrients on heat increment. Therefore, the conditions which affect this value must be understood.

The fasting metabolism of six dry, non-pregnant Holstein cows was measured in 84 24-hour respiration trials. The effects of previous plane of nutrition, type of ration, season (periods), and individuality (cows) were studied, with the basic design being a 3 x 3 Latin square and with the rations being early-cut alfalfa, late-cut alfalfa, and late-cut orchardgrass hay, each being fed as pellets. Each ration was fed at three planes of nutrition, ad libitum, maintenance, and one-half maintenance, and the total fasting heat production was measured 48-72 and 72-96 hours after the last meal.

If the fasting metabolism of the average for the three levels of nutrition is used to express the energy requirement for maintenance, a 1,000 lb. cow (98 $Kg^{0.75}$) would require 7.23 therms of net energy. If the fasting metabolism following each of the planes of nutrition fed were used, a cow receiving forage ad libitum would require 7.5 therms per 1,000 lb., one on maintenance rations would require 7.2 therms, and it would be 7.0 therms following one-half maintenance ration. These data, therefore, indicate the previous level of nutrition has an effect on the maintenance value obtained by fasting.

An entirely different requirement is obtained if the "theoretical fasting metabolism" is calculated by extrapolating to zero intake from heat production measurements made for the different rations at various planes of nutrition. Regression equations were computed for each ration, and the theoretical heat production at zero intake was 57.1 $kcal/W_{kg}^{0.75}/24$ hr. for early-cut alfalfa, 56.8 for late-cut alfalfa, and 53.0 for late-cut orchardgrass. The net energy requirements for maintenance of a 1,000 lb. cow would

then be 5.6, 5.6, and 5.2 therms, respectively, for early-cut alfalfa, late-cut alfalfa, and late-cut orchardgrass. The difference between these estimates (actual fasting as compared to extrapolation to zero intake) is due to the difference in the efficiency of utilization of metabolizable energy above and below maintenance. The lower values obtained by rectilinear regression rather than by direct measurement of fasting metabolism reflect the lower efficiency of utilization of metabolizable energy for body gain (lipogenesis). This is primarily because of the "sparing action" of body tissue which is catabolized when less than a maintenance level of feed is consumed. (AH h2-8)

3. Net energy values of selected forages. The net energy values for the all-forage rations fed in the previous experiment have been calculated using different bases for computing heat increment. The highest net energy values were obtained when the fasting metabolism measurements were used as the base, and the lowest values resulted when the heat production of animals being fed at approximately maintenance level was used as the base for calculating heat increment. The efficiency of utilization of metabolizable energy varied from 48% to 71%, depending upon which base was used to compute heat increment.

Regression equations were calculated to obtain the mean heat increment for each ration. This amounted to 0.985 kcal/gram dry matter for early-cut alfalfa, 0.886 for late-cut alfalfa, and 0.804 for late-cut orchardgrass. The mean metabolizable energy values at maintenance were 2.132, 1.833, and 1.788 kcal/gram dry matter, respectively, for the early-cut alfalfa, late-cut alfalfa, and late-cut orchardgrass. The net energy values at maintenance, therefore, are 1.147, 0.947, and 0.984 kcal/gram dry matter, or 52.1 therms/100 lb. early-cut alfalfa, 43.0 therms/100 lb. late-cut alfalfa, and 44.7 therms/100 lb. late-cut orchardgrass hay, expressed on a dry matter basis. The average efficiency of utilization of metabolizable energy ($\frac{NE}{ME}$) using these values is 53.8%, 51.7%, and 55.0%, respectively, for each of the three rations.

Regressions were also calculated to determine the relationship between metabolizable energy intake and retention or loss of energy. Correlation coefficients of 0.975, 0.967, and 0.959 ($n = 18$ in each case) for early-cut alfalfa, late-cut alfalfa, and late-cut orchardgrass, respectively, were obtained. The average efficiency of utilization of metabolizable energy over the entire range of one-half maintenance to ad libitum was 56.2% for early-cut alfalfa, 58.1% for late-cut alfalfa, and 56.7% for late-cut orchardgrass. These results indicate that there was no significant difference in the efficiency of utilization of metabolizable energy for fat deposition which could be attributed to the type of forage.

4. Metabolizable energy requirements for maintenance. The maintenance requirement of dry, non-pregnant Holstein cows receiving all-forage rations was also calculated from data in the previous experiment. If the rectilinear regression of energy retention to zero is used, the mean maintenance requirements, expressed as therms of metabolizable energy per 500 $Kg.^{0.75}$, varied with rations, being 11.3, 12.4, and 11.0 for early-cut alfalfa, late-cut alfalfa, and late-cut orchardgrass, respectively. For a 1,000 lb. cow, this amounts to 10.5, 11.5, and 10.2 therms of metabolizable energy to prevent loss of body tissue.

The maintenance requirement was also calculated by correcting to zero energy balance by multiplying the energy balance by factors ($c = 1.61$ for positive balance; $c = 1.43$ for negative balance) and adding or deducting that amount from the metabolizable energy consumed. The mean values, expressed as Mcal. metabolizable energy/500 $Kg^{0.75}$, for each plane of nutrition (ad lib, maintenance, one-half maintenance) and ration were as follows: Early-cut alfalfa, 11.4, 10.8, 10.7; late-cut alfalfa, 12.3, 11.5, 11.2; late-cut orchardgrass, 11.0, 10.0, and 10.1. There were no statistically significant differences due to ration, cows, or periods except on half maintenance rations. There was a period effect on one-half maintenance, and this was due to the exceptionally high maintenance requirement of one cow in period I, immediately after she stopped lactating. This same cow also had an apparently high fasting metabolism during the first experimental period. The conclusion drawn from these studies was that the stage of maturity and type of forage did not appreciably affect the utilization of metabolizable energy for maintenance. (AH h2-8)

5. Ad libitum consumption of forages. The ad libitum consumption of the all-forage rations was measured, and the late-cut alfalfa hay pellets were consumed in the largest quantities, followed by early-cut alfalfa hay pellets and late-cut orchardgrass hay pellets. The average dry matter consumption per unit of metabolic body weight (grams dry matter/$W_{kg}^{0.75}$/24 hr) was 87.2 for early-cut alfalfa, 102.8 for late-cut alfalfa, and 84.3 for late-cut orchardgrass. The gain in body tissue resulting from the ad libitum consumption of the forages, expressed in megacalories/24 hr. was 5.7 for early-cut alfalfa, 5.7 for late-cut alfalfa, and 2.9 for late-cut orchardgrass. Therefore, even though the digestibility, metabolizable energy, and net energy values of the late-cut alfalfa, and late-cut orchardgrass hay were very similar, the late-cut alfalfa hay was markedly more acceptable to the cattle, resulting in much greater consumption of feed and tissue deposition. There was a highly significant difference between cows in their consumption of the rations, and the differences between rations were also highly significant ($P < 0.01$). (AH h2-8)

6. Utilization of energy by lactating dairy cows. Energy balance experiments with lactating cows were initiated in 1962 to study the efficiency of utilization of energy of rations with varying hay:grain ratios. The rations consisted of (1) 100% alfalfa hay wafers, (2) 75% alfalfa + 25% concentrates (corn-soybean oil meal mixture, (3) 50% alfalfa + 50%

concentrates, with the proportions being calculated on an estimated net energy basis. The results of the experiments are not complete, but preliminary summarization of the data indicates that the efficiency of utilization of metabolizable energy for lactation for all forage rations is less than for those containing concentrates if a fixed maintenance requirement (131 kcal M.E./$W_{kg}^{0.75}$/24 hr.) is assumed.

The maintenance requirements of lactating cows, as determined by rectilinear regression to zero energy balance, are higher than for dry, non-pregnant cows, according to the results obtained to date. The overall mean of 31 observations with lactating cows indicates that the maintenance requirement is approximately 17 megacalories of metabolizable energy per 500 $Kg^{0.75}$ as compared to 11-12 mcal M.E./500 $Kg.^{0.75}$/24 hr. for dry cows.

The experiments are still in progress and the same animals will be used in further studies with these rations after they complete their lactation periods. (AH h2-8)

7. Development of analytical methods used in energy balance trials. It is necessary to continually review and study techniques and methods used in order to improve accuracy, to decrease the time required for each determination, and to tie the methods used, if possible, into the computer system by automatic recording.

(a) Gross energy. The routine method of preparing samples for gross energy analysis has been to dry them. Previous experiments on methods of storage and preparation of fecal samples showed that only slight losses of energy occurred during drying, so this procedure was adopted in preference to the use of primers. Urine and milk samples were dried in several different manners, and the results were comparable whether the drying temperatures were 20°C or 65°C. No difficulties in combustion were encountered, even though cellulose blocks or other primers were omitted during the sample preparation.

(b) Carbon. Further advancements have been made in the use of the induction furnace and gasometric analyzer for determining the carbon content of feeds, excreta, and milk. It is now possible, as a result of modification of the equipment and the use of different catalysts, to use this method for wet materials such as urine, milk, and fresh feces and obtain agreement between replicates without drying them, which considerably reduces the time required for the determination. It was necessary to modify the combustion tube and the catalysts before quantitative recovery of carbon from wet materials could be obtained.

It was found that urine and milk samples could not be stored without changing the carbon values, even though they were frozen or refrigerated after being

weighed. The routine procedure adopted was to analyze all urine and milk samples immediately. Since a sample can be analyzed in approximately eight minutes, this did not present a major problem. (AH h2-8)

8. Development of chemical methods for determining the nutritive value of feeds and forage. The nutritive value of forages in particular varies markedly dependent upon stage of maturity, species, method of preservation, and fertilizer practices. Thus it is highly desirable to have rapid chemical methods which will predict the nutritive value of forages. Work in this area has been in progress for about ten years at Beltsville and it now appears that a breakthrough is in the making.

(a) Acid-detergent fiber and lignin. During the past year further analyses were made using the new acid-detergent fiber and lignin procedures. The acid-detergent fiber has compared favorably with the AOAC crude fiber on 72 forages of known digestibility. Correlations were -0.79 for the new method and digestibility and -0.70 for the AOAC method and digestibility. Correlations using the lignin figures have not been made because of large interspecies variation.

A regression equation has been calculated for estimating crude fiber from acid-detergent fiber in order to provide a basis for comparing present results with older data. The relationship is: crude fiber = 3.56 + 0.75 x acid-detergent fiber. (AH h2-6)

(b) Effect of heating and drying of forages and feces on analyses. Other studies have been made comparing the effects of heating and drying upon the yield of acid-detergent fiber and lignin. Data show that the acid-detergent fiber from unheated forages contains 2-20 percent of the total plant nitrogen. This nitrogen has a low in vivo digestibility and is associated with the lignin fraction. When forages are heated or dried, the fraction insoluble in 72% H_2SO_4 tends to increase along with the nitrogen content at a ratio of 9.16 of lignin dry matter to nitrogen. Evidence suggests the condensation of carbohydrate residues with amino acids in the non-enzymic browning reaction to form dark colored acid-insoluble polymers. Corrections have been devised for the analysis of feed materials which have been excessively heated in order to estimate the true lignin content. (AH h2-6)

(c) Estimation of digestibility using lignin ratio technique. Previous studies have shown that lignin, using previously published methods, gave variable results when used as a marker in the ratio technique for determining digestibility.

Studies have been made using the new detergent lignin as a measurer of digestibility using the ratio technique. A comparison with chromium oxide in 22 total collection trials with cows gave a correlation of +0.96 between digestibility estimated by lignin ratio compared with total collection,

whereas the corresponding correlation for chromium oxide was +0.91. Recoveries of both detergent lignin and chromium oxide were close to 100 percent. Thus the new detergent lignin procedure would appear useful in pasture studies and other experiments involving digestibility by ratio techniques. (AH h2-6)

(d) Relationship of forage composition to voluntary intake. A study of the lignin and detergent fiber contents of 83 forages from West Virginia representing 7 species has been made. These forages are from digestibility and voluntary intake trials conducted after the manner of Crampton using nutritive value index. An analysis of covariance showed that the relation between intake and digestibility is not consistent and may be a species characteristic such as lignin is known to be. Neither acid-detergent fiber, nor detergent lignin, were good predictors of intake, and other analyses for this purpose should be sought. Consequently, the attempt to predict nutritive value index directly from laboratory analyses is not considered feasible. (AH h2-6)

9. Influences of high protein on the heart rate of dairy cows. Data collected at Beltsville and elsewhere indicate that the maintenance requirement for a grazing cow is greater than for the same animal stanchioned in the barn. It had been suggested that this requirement could be due to increased intake of protein with a resulting increase in heat increment. Two groups of cows were fed a pelleted ration containing 26 and 10% protein in a reversal experiment. Heart rates were taken as a measure for possible increased heat production. No difference was detected between the two groups. It was concluded that increased protein intake per se is not the major factor concerned with increased maintenance requirement of grazing animals. (AH h2-8)

10. Chemicals in milk.

(a) Effectiveness of hydrobiotite on in vivo removal of radionuclides from milk. A pilot study to determine the effectiveness of hydrobiotite (Vermiculite) in the ration on the excretion pattern of radionuclides (Cs^{134}, Ba^{140}, Sr^{85}, Ca^{47}, I^{131}) was conducted. The inclusion of hydrobiotite at the rate of 1.5 lbs. per day (3% of the total ration) resulted in a marked reduction of radioactive cesium, barium, and strontium in the milk. In vitro and in vivo tests with I^{131} were negative for all grades of hydrobiotite tested. One unexplained observation made in the pilot studies was that the hydrobiotite apparently caused mobilization of bone and tissue stores of Sr^{85}, as evidenced by an initial increase in the Sr^{85} in the milk followed by a more rapid decline in concentration than in the control period. Two cows and eight laying hens were used in the pilot studies, and replications showed that hydrobiotite is effective in influencing the excretion pattern and metabolic fate of these cations. (AH h2-8) (Also see Area 1)

(b) Concentration of thiodan in milk from residues on sprayed Coastal Bermuda grass. Coastal Bermuda grass was sprayed with 4, 8, and 16 ounces of thiodan per acre. The Bermuda grass was harvested 7 days later and placed in tower silos with the addition of 100 lbs. of ground ear corn per ton of forage as an aid to preservation of the silage. The silage was fed out beginning 78 days later to lactating dairy cows over a period of 3 weeks. During this storage period about 2/3 of the thiodan disappeared from the silage. The silage as fed contained 1.24, 1.89, and 6.43 ppm of thiodan on a dry matter basis for the 4, 8, and 16 ounce rates of spraying. No thiodan residues were found in the milk. Therefore, it is concluded that forage sprayed with thiodan and ensiled does not result in thiodan residues appearing in the milk. Considerable thiodan disappears from the ensiled forage during storage in the silo. (AH h2-9)

B. Forage Evaluation and Utilization

1. Silages

(a) Storage structures

(1) Storage of low-moisture silage in conventional tower silos. Excellent quality high dry matter silage was previously produced in conventional tower silos by following somewhat unusual filling and sealing procedures. This experiment was extended by investigating whether an excellent product could be obtained by more simplified procedures.

First-cutting alfalfa was mowed, conditioned, and harvested as either barn-dried hay or as low-moisture silage (about 45% dry matter) stored in two upright silos. The usual good filling procedures were followed and distribution in the silo was limited to occasional manual leveling in one silo and mechanical distribution in the other. This resulted in 88 and 92% dry matter preservation, low ammoniacal N production, and a limited fermentation predominantly lactic acid. The low temperatures observed and considerable residual sugar were also characteristic of a well-controlled atmosphere. The feeding value of these silages for milk cows and heifers and digestibility for sheep was equal to the companion hay.

The results were similar in all respect to those of the previous year. Thus, it appears that low-moisture silage can be successfully made in conventional tower silos with the application of the usual good ensiling practices. This means that the weather losses and hand labor associated with hay making can be economically eliminated or reduced by most farmers. (AH h3-3)

(2) Storage of low-moisture alfalfa in bunker silos. Successful storage of low-moisture alfalfa in conventional tower silos and wilted alfalfa in a bunker silo suggested that alfalfa at about 50% dry matter might be stored in a bunker.

Second-cutting alfalfa in full bloom was mowed, conditioned, wilted to an average dry matter content of 47% (range 24-70), chopped short, and stored in a bunker. Both bunker walls were lined with plastic and the excess on one side was put under the top seal (envelope seal) while the excess on the other wall was placed on top of the top cover (overlap seal).

More than 90% of this forage was recovered for winter feeding. Visible spoilage losses were 3.6% and occurred mainly on the side of the silo with the overlap seal. Maximum temperatures of 105°F were observed soon after filling. The chemical quality was excellent and typical of well-preserved haylage. No critical evaluation of feeding value was made.

The storage of low-moisture alfalfa silage in a bunker was clearly successful. This work should be extended to fully evaluate the possibilities of producing the best silage (high dry matter) with a minimum silo investment. (AH h3-3)

(b) Factors affecting silage quality

(1) Effect of pre-ensiling air exposure on quality of orchardgrass silage. Field wilting of forage involves exposure of the crop to air as well as a reduction of moisture content. While the overall effect is usually an improved silage, the effect of exposure has not been distinguished from that of moisture reduction.

Third-cutting orchardgrass, both chopped and ground, was exposed to air from 0-8 hours before being ensiled in one quart silos. Restricted circulation during this period minimized moisture loss. This type and length of exposure had no significant effect on silage from the ground forage, but a marked deleterious effect on chopped forage exposed for 8 hours was noted.

These results suggest that the benefits derived from fast wilting may be greater than those from slow wilting. If true, this might be of considerable importance when attempting to wilt to a 50% moisture level. (AH h3-3)

(2) Effect of antibiotics on orchardgrass silage. Interest in improving the fermentation pattern of high-moisture direct-cut silage continues. Tylosin and zinc bacitracin treated silages were compared to a control silage using third-cutting, nitrogen fertilized orchardgrass ensiled in steel 4' x 8' silos. No beneficial effects of either antibiotic were noted since all silages, including the control, were of good quality. Reliable methods of producing poor quality control silages for such experiments are needed. (AH h3-3)

(3) Effects of various mechanical treatments on specific gravity, losses and quality of orchardgrass silage. A distinct improvement in chemical quality of silage has been noted from fine grinding forage previous to ensiling in quart jars. The effects of grinding, very fine chopping, and laceration were compared with respect to the

improvement of fermentation over that achieved by regular chopping. Fine chopping, laceration, and grinding produced increasingly greater specific gravity as compared to chopping. pH, ammoniacal nitrogen, and acetic acid after ensiling were significantly negatively correlated with specific gravity before ensiling. Thus, the beneficial effect of mechanical treatments on fermentation can be assessed by measurements of increases in specific gravity of the forage caused by the treatment. Dry matter loss and CO_2 loss was also favorably affected by increasingly severe mechanical treatments. (AH h3-3)

(4) Effect of laceration on preservation and feeding value of grass-legume forage. This work is an extension of laboratory studies, which had shown beneficial effects from laceration on silage quality, to a farm silo situation. Lacerated and non-lacerated forages were compared in farm size silos at Lewisburg, Tennessee. This report gives results for the second year of study. Some small differences in favor of the lacerated silage in chemical quality were noted. For instance, the pH of the control was 4.36 compared to 4.03 for the lacerated. In the same order the butyric acid was 1.25 vs. 0.29%, lactic acid 6.5 vs. 7.7%, ammonia nitrogen as protein 2.8 vs. 1.8. There were no differences in feeding value in terms of dry matter intake or milk production. These results agree with those obtained in the previous year. It can be concluded that laceration of forage has no advantages where the forage is stored in a tower silo. It seems probable that the weight and pressure of the forage probably produces a "laceration effect" automatically in a tower silo. The possible advantages of laceration of forage to be stored in horizontal silos where pressure is not so great should be investigated. (AH h3-3)

(5) Effect of nitrogen fertilization on silage quality. The variation from year to year in silage quality which results from ensiling an apparently similar crop by the same methods is a matter of concern to both researchers and farmers. The role of crop fertilization in creating these differences was investigated, using first-cutting orchardgrass. Grass fertilized with 400 lbs. of ammonium nitrate on April 27 was direct-cut and ensiled in comparison to the same crop without nitrogen fertilization. The fertilized forage contained 23% crude protein when harvested at full-head stage (May 15-17) and the unfertilized contained 13%. The fertilized forage was also lower in dry matter, crude fiber, and sugar content.

Silage from the fertilized crop was higher in ammoniacal nitrogen, butyric acid, and pH. The poorer quality was also evidenced by lower consumption by dairy cows and by weight loss. The effect of nitrogen fertilization on silage consumption was more marked than it was in a previous experiment. This is explained to a large extent by the greater effect of nitrogen on the chemical composition of the silage in the present experiment.

The effects of fertilization were further studied in 4' x 8' silos. In this study 800 lbs. of ammonium nitrate per acre produced even greater changes in plant composition and deleterious effects on fermentation products, particularly between the first and eighth week of storage. Initial nitrate contents

of 1 - 1.7% were observed in the 400 and 800 lb. fertilization treatments but were reduced to near zero during 8 weeks of storage. Sodium nitrate added at the time of ensiling had little effect on the chemical quality of control silage. The added nitrate remained at a high level in the control silage. This has since become regarded as typical of nitrate in a low pH silage. The poor chemical quality produced by fertilization did not display high counts of anaerobic spore formers as was the case when poor quality was produced by aeration.

The production of poor quality silage by nitrogen fertilization of the crop suggests that the practice should be combined with the use of silage preservatives or wilting. Lowered silage intake rather than toxicity has been the prominent hazard in these highly fertilized silages. (AH h3-3)

(c) Yield and feeding value of silages

(1) RS-610 grain sorghum and starr millet as silage. At Lewisburg, Tennessee, the yield, preservation, and feeding value of 610 grain sorghum and starr millet were compared when harvested as silage. The 610 grain sorghum yielded 4 tons of dry matter while the millet yielded 3 tons of dry matter per acre. 88.7 and 97.4% of the dry matter, respectively, was preserved as silage for feeding. Milk production in the same order was 37.7 and 34.2 FCM daily. The first year's data show a considerable difference in yield for the two crops but no significant difference in feeding value. (AH h3-12)

(2) Relative feeding value of four silages. At Willard, North Carolina, four different crops were harvested as silage. The four crops were mature corn, drilled immature corn, Hegari sorghum, and Gahi millet. The drilled immature corn had 232 lbs. of ground ear corn added at the time of ensiling, which amounted to 36.1% of the dry matter of the silage. The relative feeding value of the four silages was determined in trials with lactating cows and growing heifers and in a metabolism trial with steers.

The dry matter intakes of immature corn and Hegari sorghum by the heifers were similar, and were significantly higher than those observed for mature corn and millet. However, the lower intake of mature corn was not reflected in average daily gain with only the gain on millet being significantly inferior.

In the lactation trial, dry matter intakes of Hegari sorghum were higher than those for the other silages. Intakes of mature and immature corn were similar, with millet significantly lower. FCM production was similar for all silages except millet, which was significantly lower. Weight gains on Hegari appeared to reflect the higher silage intake, but were not significantly different from the others.

No significant differences were noted for the dry matter or crude protein digestibility or for nitrogen retention by the steers in the metabolism trial.

Thus, millet silage was markedly inferior to the other three in both growth and lactation trials. Although immature corn compared favorably in feeding value with mature corn and Hegari, probably one-third of the dry matter fed out came from the ground ear-corn additive. (AH h3-9)

(3) Yield of sorghum silages. In the southeast area of the United States, because of the relative uncertainty of corn as a silage crop, as a result of occasional drought conditions, considerable attention is now being given to the value of sorghums as a silage crop. At Willard, North Carolina, the relative yield of Sart and Hegari sorghums were compared to corn for silage.

The yield of Sart sorghum, Hegari sorghum, and corn were 6.04, 13.0, and 5.6 tons of dry matter per acre.

Thus, although wet yields of Sart exceeded those of corn, dry matter yields were essentially the same. Hegari yields were poorer in previous years, but some additional forage was obtained in a second cutting.

The plant separation data confirms the high stalk percentage and low grain proportion of Sart compared with corn and Hegari. It also points out the possible effects of seeding and harvest time on plant composition, even though the stage of plant at harvest was similar.

Feeding trials are in progress to evaluate these silages and to see if production of animals fed Sart can be made to equal corn with additional concentrate feeding. Two plastic bag silos of Sart with ground corn cobs added to one as a preservative will also be compared. (AH h3-8)

(4) Utilization of silage protein. Two silages from the same field containing 25.6 and 14.4% crude protein were fed to sheep in digestibility trials. The high protein silage was produced by fertilization with 400 lb. of ammonium nitrate per acre. The animals on the control silage (no nitrogen fertilization) showed positive nitrogen retentions although the ration was deficient in energy and provided only a borderline level of intake in relation to requirements. The sheep on the high nitrogen silage retained 94% more nitrogen than when on the control silage. The amount of protein retained for the two silages was 39 grams for the high protein silage and 17 grams for the control. While it is well known that much of the nitrogen in silage is non-protein nitrogen and is in the form of ammonia, amide and amine nitrogen, yet the sheep in this experiment on the control ration utilized the nitrogen efficiently. (AH h3-3)

(d) Biochemical studies relating to silage investigations

(1) Determination of nitrate in silages. The development of a chemical method that will result in reliable values for the nitrate content of plant material has been needed for several years. A method has now been worked out, data summarized, and a paper prepared for publication.

Better recovery of nitrate from charcoal - Celite columns has been found with phosphoric acid rather than sulfuric acid in the initial eluent. Phosphoric acid, on the other hand, was found to be less effective than dilute sulfuric acid in extraction of nitrate from plant material. However, dilute phosphoric acid containing 4% of sodium sulfate proved fully as effective as dilute sulfuric acid for extraction. In the elution of nitrate from charcoal columns it was found that the concentration of sodium bicarbonate in the eluent could be reduced from 1.0 to 0.1%. The reduced level of bicarbonate resulted in smaller dried salt residue and consequently speedier solution by the nitration solvent. Nitrite interference was found to be easily eliminated by addition of sulfanilic acid to the nitrate solution before chromatography. (AH h3-1)

(2) Determination of sugars. The need for the development of a stoichimetric colorimetric method for the determination of sugars has been widely recognized. The use of toluidine in acetic acid as a reagent to give equal response per molecule of sugar has been investigated. The effect of borax as a catalyst in the reaction of the reagent gave an equivalent response for glucose and sucrose. Further study showed that for lactose, marmose, and xylose, the respective ratios to glucose were 1.04, 0.98, and 1.16 which is essentially within the experimental area of exact agreement. Galactose, however, gave an aberrently high response which was not encountered with lactose. Treatment of the final reaction brought the ratio for glactose into line with the other sugars. Further tests are in progress for pentoses, methyl pentoses, and various other sugars to study the general applicability of the reaction. Present data indicate that the reaction may not yield a stoichimetric method only for mixtures of aldoses but also for ketoses. A further advantage for the reagent is that the disaccharides may be determined directly without prior hydrolysis. (AH h3-1)

(3) Nitrate disappearance in silage. The nitrate content of hay-crop silage decreases during the early stages of fermentation and subsequent storage in the silo. The factors that affect the degree and rate of decrease are not well understood. In experiments to study those factors, the nitrate level of orchardgrass was followed through the ensiling process in 10' x 35', 4' x 8', and quart jar silos. The results showed that a high pH type of fermentation that takes place in high-moisture silage will almost completely remove nitrate from the forage. Wilting the forage in the field prior to ensiling tends to prevent nitrate disappearance from the silage. The addition of sugar to high-moisture forage tends to prevent nitrate disappearance. Grinding or masceration of the forage facilitates the removal of nitrate in the early stages of the fermentation.

As a result of these studies, it has been suggested that nitrate removal from direct-cut silage may take place in two stages in the fermentation. Some disappears shortly after the silage is placed in the silo before the pH becomes lowered. Laceration hastens disappearance at this time and may result in almost complete removal. Then after a period of storage more nitrate disappears if the pH for some reason becomes elevated. (AH h3-1)

(4) Effect of herbicides on the quality of silage. It has been known for some time that the treatment of crops with herbicides will result in an increase in sugar content of the crop. It is also known that the sugar content of forage at the time of ensiling improves the quality of the silage produced due to the production of a desirable type of fermentation. Therefore, it was proposed to study the effect of spraying forages with herbicides on the quality of the resulting silage. Alfalfa was sprayed with 2 different herbicides and orchardgrass was sprayed with 3 other herbicides and the resulting forage placed in quart jar silos 0, 1, 2, and 4 days after spraying. The lactic acid content of the resulting silage was used as an index of quality. The results showed that some of the herbicides definitely increased the lactic acid content of the silage, the greatest effect usually occurring on the second and fourth day after spraying. The results were most encouraging and suggest that further study is highly desirable. (AH h3-1)

2. Pastures

(a) Stocking rate of dairy cows on orchardgrass ladino clover pasture. A study of the effects of intensive, moderate, and liberal grazing pressure on rotationally grazed pastures on the productiveness of the pastures and milk production by dairy cows has been continued at Beltsville for a third year which completes the experiment. Effects on cows, plants, and acre yields were obtained in cooperation with the Forage Crops Branch.

The data from tester cows indicated that the digestibility of forage was lowered slightly but significantly by more intensive grazing. Digestibility was significantly higher at the beginning of the grazing season. Intakes of dry matter, digestible dry matter, organic matter, and digestible organic matter were lowered by intensive grazing to a small and insignificant extent. These findings were in accord with the finding that levels of milk and FCM production were not significantly different between treatments.

Further interpretation of the data, including effects on production per acre of forage and animal products, is underway. (AH h3-18)

(b) Coastal Bermuda grass for lactating dairy cows. At Willard, North Carolina, in the coastal plains area, permanent type pastures do not produce well. Because of this, considerable attention has been given to the use of annual crops in the pasture program. However, because Coastal Bermuda

grass has increased in popularity as a permanent type of pasture for beef cattle, it was thought desirable to study the use of the grass with dairy cattle. A comparison was made between rotationally grazed Coastal Bermuda grass, rotationally grazed Starr Millet and dry lot feeding of corn silage as the forage. Results for the second year of the study are reported. Jersey cows produced 28.1, 31.1, and 28.4 lbs. of FCM per day on the Coastal Bermuda grass, Starr Millet, and corn silage, respectively. Percent decline for a four-week period was 10.9, 10.0, and 7.9%, respectively. Gain or loss of body weight was -0.03, -0.03, and +0.29, respectively. For this year Starr Millet was superior for milk production. (AH h3-10).

(c) Stored forage compared to rotational grazing for lactation. It has been suggested with the increased development of silage harvesting equipment and automatic silage unloaders that there might be some advantage to harvesting the forage rather than pasturing it. At Lewisburg, Tennessee, a comparison of this type has been in progress using a field seeded to orchardgrass, ladino clover, and alfalfa. At the end of 3 years the plant population for the stored forage and pasture plots were alfalfa 34.1 vs. 16.7%, orchardgrass 35.5 vs. 45.5%, ladino clover 25.2 vs. 28.1%, and weeds 5.3 vs. 9.7%. Milk production per cow has been in favor of the pastured animals while milk production per acre has been slightly in favor of the stored forage fed cows. (AH h3-12)

3. Relative feeding value of wafered and baled alfalfa. Harvesting and feeding of hay in the form of wafers have attracted considerable attention recently. This interest has been based primarily on the physical advantages of handling hay in this form while the nutritional status of wafers has been less clear.

Field-cured hay was field cured and then baled or wafered with a Ford machine. Milking cows consumed more dry matter and produced more milk when fed the wafers. The wafers contained less crude fiber and more crude protein when fed. This is suggestive of less leaf loss in the wafering process. From this limited trial it appears that any nutritional advantage of wafers over baled hay may lie in differential mechanical losses and/or greater ad lib intake. (AH h3-3)

C. Calf and Heifer Feeding

1. Rumen content relationships with silage and hay rations. In previous experiments the preservation of forage as direct-cut silage has resulted in lower dry matter consumption and lower weight gains by dairy heifers than results from feeding hay. The storage of forage as direct-cut silage has usually resulted in a decrease in both the content and solubility of carbohydrate and an increase in both the content and solubility of the nitrogen. It might be expected that if there was an increase in acid-detergent fiber in direct-cut silage as compared to hay, it would reduce the rate of digestion and the rate of disappearance from the rumen and, therefore, be a major factor in differences in intake.

The current experiments were undertaken to determine the relationship of the feed composition, digestibility, and passage from the rumen to feed intake of direct-cut silage and hay harvested at the same time from similar areas. Secondly, these experiments have explored the effects of lower nitrogen utilization observed when feeding direct-cut silage compared to hay on growth rates of dairy heifers. In this experiment the preservation of forage as high-moisture silage increased the lignin, acid-detergent fiber, total Kjeldahl nitrogen, and ammoniacal nitrogen compared to preservation as hay. The silage showed reduced dry matter and organic matter digestibilities but equal energy and nitrogen digestibilities.

The hay and silage was fed at maintenance and ad libitum levels of intake. Ad libitum hay dry matter intake was significantly higher than ad libitum silage dry matter intake. When the entire rumen content was removed at certain hours after feeding, the highest level of both wet or dry rumen content was observed on the ad libitum hay ration. Identical rumen retention times were observed for ad libitum silage and hay. Feeding hay or silage restricted to maintenance intake gave rumen retention times similar to each other but somewhat greater than ad libitum feeding. Adjusting the rumen retention time on ad libitum silage for the effect of the slightly lower consumption observed on ad libitum hay would tend to give it a shorter retention time than observed for hay. Dry matter disappearance measured by direct removal from the rumen which measures the sum of the two rates of disappearance, i.e., digestion with absorption from the rumen and passage down the tract, was not significantly different for hay and silage rations. These data suggest that accumulation of rumen residues or rumen capacity was not limiting the dry matter intake of this silage ration.

Ration effects on percentage dry matter in the rumen occurred. These resulted, in part, from the differences in level of feed intake. Ad libitum feeding increased the percentage dry matter in rumen compared to maintenance level feeding. Animal differences existed for the percentage dry matter in the rumen. Wet rumen content and dry rumen content decreased with time after feeding. No differences appeared in percentage dry matter of ad lib fed animals.

The silage contained 3.40% total nitrogen in the dry matter with 27% of the total as ammoniacal nitrogen and 23% as hot water insoluble (true protein) nitrogen. The hay contained 2.52% total nitrogen in the dry matter with 2% of the total as ammoniacal nitrogen and 61% as hot water insoluble nitrogen. The nitrogen utilization on hay was better than on silage when both were fed ad lib. This is true whether basing the comparison on grams of nitrogen retained per day, percent nitrogen retained of that fed, or percent nitrogen retained of that digested.

A second group of animals were fed continuously to measure intake and weight gain. The hay fed animals consumed more dry matter and gained more weight.

The growth of these animals and the nitrogen retention of those used in the nitrogen balance trial were combined to further study nitrogen utilization using a different concept than nitrogen retained per day as previously pointed out. In the second concept the grams of nitrogen retained per 100 grams of body weight gain were calculated. The results for silage were much above those for hay and much above those usually accepted for adequate protein supplements. The large amount of nitrogen retained per 100 gm. gain on silage suggests in contrast that body weight gain was not restricted by the lower utilization of silage nitrogen. The large amount of nitrogen retained per unit of weight gain for the silage fed animals in contrast to the lower utilization of nitrogen expressed as grams retained per day suggest that energy intake is the primary limiting factor causing lower weight gains in silage fed animals. (AH h1-1)

2. Effect of frequency of feeding milk replacer to calves. Some published data indicated the greater frequency of feeding may increase rate of gain. Calves were fed milk replacers at two levels of intake and at 2 or 4 times each day. Results obtained at Willard, North Carolina, with 12 Jersey calves showed greater gain resulted from the higher level of feeding but there was no difference in gain due to the number of times the calves were fed each day. (AH h3-11)

D. Management Practices, Equipment and Facilities.

1. Bovine mastitis.

(a) Effectiveness of antistaphylococcal vaccination. A study was made of the efficacy of antistaphylococcal vaccination in controlling mastitis. In May 1961, the station veterinarian began a program of vaccination employing a commercial multi-strain Staphylococcus aureus mixed bacterin-toxoid, Jen-Sal "Staphoid A-B", consisting of beta-propiolactone-inactivated whole cultures, among which were representatives of phage groups I, III, and IV. All cows and bred heifers were paired according to breed, age, and stage of lactation and assigned to either the treated or control group. Heifers were added alternately to the experimental groups as they became pregnant. Vaccination was carried out according to the manufacturer's recommendations.

During the succeeding year and a half the vaccinated and control groups exhibited, respectively, 41 vs. 38 chronic cases of mastitis; 17 vs. 13 acute cases. On a per-quarter basis, there were 46 vs. 39 chronic and 20 vs. 13 acute. The groups required, respectively, 204 vs. 174 treatment days. Since March 1962, when facilities for bacteriological analyses became available, the herd has been subjected to monthly quarter sampling of strict foremilk. The udder microflora was characterized quantitatively and qualitatively, and leucocyte concentration was determined. Laboratory findings of infections caused by coagulase-positive staphylococci among the treated and control groups indicate no influence of vaccination on the incidence of

infection or on its elimination. The respective frequencies were: 25.6% vs. 31.0% of cows infected, and 12.8% vs. 10.7% on a per-quarter basis; 5.7 vs. 16.1% of heifers infected, and 2.2% vs. 6.3% on a per-quarter basis. The numbers of S. aureus infections occurring among the primips were so low that, although the percentages show an interesting difference in favor of the vaccinated animals, no significance is attached to them. Mean concentrations of leucocytes (per million) were as follows for the vaccinated and control groups, respectively: 0.63 vs. 0.73 among quarters free of culturable bacteria; 4.95 vs. 4.08 among quarters positive for S. aureus.

These results show no benefits accruing from vaccination of this herd with the bacterin-toxoid. There was no difference between the groups of animals in (a) frequency of S. aureus infections, (b) incidence of clinical mastitis, or (c) severity of staphylococcal mastitis.

(b) Factors influencing leucocytes in milk. Five thousand quarter milk samples were assayed for leucocyte concentration by direct microscopic count. An estimation of reliability of counting procedure was made using a 10 field count as compared to a 27 field count. Repeatability of the 10 field count using 6 cows and 5 slides from each quarter was 0.965. The corresponding value for the 27 field count was 0.981. The ten field count was then used because of its advantage in greater speed.

Data obtained from monthly quarter samplings were analyzed in terms of leucocyte count distributions among quarters classified as uninfected or infected. The majority of bacteriologically negative quarters had leucocyte counts of less than 500,000 per ml. However, 16.6% of these counts were greater than 1,000,000 per ml.

Among quarters infected with S. aureus only 10% of the leucocyte counts fell below 1,000,000 per ml. If dairy processing plants set maximum normal counts at 200,000 per ml to indicate abnormal milk (as is being proposed by some) the then 55.9% of the culturally negative samples would have been misclassified and rejected. Of the samples positive for S. aureus, 5.7% would have been accepted. If the grading limit was set at 1,000,000 per ml., then 16.6% of the negative samples would have been rejected and 9.2% of the S. aureus samples would have been accepted.

The reasons for the large number of negative samples having high leucocyte counts could be as follows: (a) lingering inflammatory response to recent infection, (b) traumatic inflammation of non-microbial origin, (c) current infection, which was detectable culturally, or (d) other factors not readily understood. To further understand these results an analysis was made on a group of selected cows having consistently uninfected quarters. This study suggests that high leucocyte values do not reflect recent history of udder infection but to some extent, the individuality of the cow and even the quarter. Age of the animal, lactation number and stage of lactation seem to be important in the pattern of leucocyte shedding. (AH g3-8)

2. Environmental influences affecting production records. This project was initiated to develop methods for minimizing the environmental influences on production records and thus improve the records as estimates of genetic merit. The work is carried out at Beltsville, jointly with the Dairy Herd Improvement staff of the Dairy Cattle Research Branch and in cooperation with the Wisconsin Agricultural Experiment Station.

(a) Environmental variables associated with milk yield. Feeding and management data collected by fieldmen and DHIA supervisors were analyzed by simple correlation and multiple regression procedures in an attempt to determine the independent influence of management and feeding variables on herd level of production. After a series of multiple regression analyses it was found that 10 of the 53 environmental variables had important relationship to herd average milk yield. These variables were: 1. cow cleanliness; 2. recommended machine line vacuum; 3. recommended pulsation; 4. number additional helpers at milking; 5. calf feeding; 6. herdsmanship; 7. hay score; 8. percent days in milk; 9. herd size; and 10. TDN/1000 pounds weight. The multiple coefficient of determination from this analysis indicates that 65% of the variation in yearly herd average milk yield was associated with variation in these 10 environmental influences.

In each of 5 successive multiple regression analysis in which a single additional independent variable was removed from the study until in the 5th analysis only 5 independent variables remained, it was found that as variables numbered 4, 5, 1, 10, and 6 were removed the respective R^2 values found were .62, .60, .60, .58, and .43. The procedure simply eliminated, stepwise, the 3 subjectively recorded ratings, variable No. 4, which has questionable meaning and variable No. 10 which has questionable cause and effect relationships.

(b) Variations in tape weight. From 13,723 tape measurements, representing 4, 595 cows in the environmental project herds, heritability and repeatability of lactation weight were estimated from the first through sixth lactations. Heritability estimates were derived from paternal half-sib correlations. Those estimates obtained from an overall herd basis were 0.23, 0.53, 0.41, 0.79, 0.79, and 0.64, for the first through the sixth lactations, while the corresponding values obtained from a within herd basis were 0.31, 0.53, 0.76, 0.85, 0.14, and 0.40. These estimates were somewhat greater than most of those previously reported for live weight.

Repeatability estimates were high and ranged from 0.62 to 0.77, when obtained from the between cow analysis of variance; 0.61 to 0.78 when obtained from a between sire analysis; and 0.57 to 0.74 when obtained from the between herd analysis of variance. These values were similar for each lactation.

These results were not conclusive in determining which single month would be most reliable in estimating lactation weight. It was apparent that the first

month of lactation was the least reliable month to obtain average lactation tape-weight because both the tape and scale weight overestimates average lactation tape-weight and because appreciably greater variation in tape-weight existed during the first month of lactation.

(c) Variations in DHIA test-day production: The monthly test-day yield involving 4,167 lactation records made in the environmental project herds from September 1958 to October 1962 were evaluated in studying variations in test-day production involving DHIA herds. Each test-day production, including the first, was expressed as a percentage of that of the previous month and the effect of age at calving, season, and year of calving, and level of production on these values, was determined by a least squares analysis of variance. Age was highly significant in its effect on test-day changes in fat production, while season of calving showed significance only in early and late stages of lactation. Year and level of production had no significant influence on test-day changes in fat yield.

Test-day change figures for each month appeared to have a normal distribution about their means, with the possible exception of the last month of lactation. The amount of variation associated with test-day change varied with month of lactation. The 2nd, 9th, and 10th months had the greatest variability, and months No. 4, 5, and 6 were least variable.

Nurse cow tables were derived, based on the average lactation curves for test-day milk yield. It was concluded that the highly significant effect of age on test-day changes could be adequately accounted for by having two nurse cow tables, one representing ages of less than 36 months and the second ages greater than 35 months.

The results of this study indicated that DHIA processing centers should give serious consideration to automating the adjustment of production credits of cows assumed to be abnormal at approximately the one percent level of probability. This would be considerably less than the 2.87% which could be adjusted based on the existing 40% DHIA rule. It was further suggested that such adjustments be made without regard to indicated abnormality remarks by the DHIA supervisor, since these results showed that in Wisconsin DHIA such remarks are highly selective.

(d) Evaluation of herd averages. The production data collected from the environmental project herds between November 1958 and January 1962 were used in evaluating variations in different methods of computing DHIA herd averages. It was found that in computing DHIA herd average production the adjustment for back credit is unimportant in the monthly and in the current month of the twelve-month rolling DHIA averages.

Monthly and twelve-month rolling averages for milk and fat yield were regressed on the corresponding percent days in milk, stage of lactation, herd size, and herd age. These variables accounted for approximately 39, 30, .1,

and 0 percent of the variations, respectively, in monthly milk and fat yield. It was concluded that percent days in milk and stage of lactation were important sources of variation in monthly production averages. A similar analysis involving twelve-month rolling herd averages indicated that stage of lactation was an important source of variation. It was estimated that 12 and 6% of the variation in monthly milk and fat yield, respectively, was attributed to year, season, and year x season interactions. Year x season interactions were highly significant for monthly milk and fat yield and stage of lactation. Year and season influences were highly significant sources of variation in percent days in milk.

Each of ten months of computing herd averages from lactation data was compared to the corresponding twelve-month rolling DHIA herd averages for the 46 herds over 3 years. It was found that M.E. extended lactation records based on all available lactations were at least as adequate as 9 other methods of defining herd averages based on lactation records in predicting the level and in ranking herds according to the DHIA rolling herd average. The multiplicative factor derived from these data in attempting to convert lactation averages to actual or DHIA rolling averages was 1.06. It was apparent, however, that relatively large errors would be made in using this factor on an individual herd basis.

(e) Selection of females. During the years 1959-1960 and 1961, a total of 5,218 calves were born in the project herds. Of these, 48.0% were heifers, 48.5% were bulls, and 3.5% were not identified as to sex. An inventory of 794 heifers born in 1959 and compiled 2-1/2 years later indicates that, from 45 to 50% of the heifers born in DHIA herds such as those in the environmental project, eventually freshen into the herd.

An attempt was made to characterize the project herds as to why cows in milk leave the herd and the extent to which their removal is associated with production levels. The 41% leaving the herd because of culling or selection were significantly inferior to their herd mates by approximately 1,100 lbs. of milk and 50 lbs. of fat. This level of inferiority, or culling effectiveness, was similarly evident both when all available and first records were involved in the analysis. The production inferiority of cows culled from the herd for reasons other than low production was considerably less and not highly significantly different from that of their herd mates. These results strongly indicate that in the herds enrolled in the environmental project, some degree of effectiveness has been realized in the selection or culling of milking females. It was also apparent that cows eventually to be culled from herds could be effectively evaluated and culled on the basis of their first records. (AH g5-1)

3. Antibodies in milk. The purpose of this work is to determine if absorption and/or protection occurs when milk containing antibodies is ingested by humans or livestock.

The udders of 10 cows were infused with bacteria (heat-killed, phenolized Escherichia coli - Norden Strain 158 or Proteus mirabilis) at weekly intervals from 250 days of gestation to parturition. Each quarter received a suspension of 5×10^9 bacteria in 25 ml. of sterile saline. A rise in antibody titer occurred in the blood and milk. Milk titers were highest in colostrum with peaks as high as 262,000. It has been reported that antibody milk protected calves against lethal oral doses of E. coli (Norden Strain 158). However, in the present study, oral doses of up to 465×10^9 bacteria failed to cause ill effects in 11 calves ranging from 5 to 38 days of age. Studies on 8 one-month-old calves indicated that intravenous doses of 7×10^9 E. coli were lethal. Nine pairs of one-month-old calves were challenged with 7×10^9 live E. coli intravenously after one of each pair consumed 14 lbs. of antibody milk per day for five days. Antibodies could not be detected in the blood of these calves after drinking the milk. Two of nine calves drinking the antibody milk survived. One control calf survived. Ten adult human males drank a quart of antibody milk a day, a pint at a time, for six days. Tests of blood samples taken before and after the milk was consumed failed to indicate that antibodies had passed into the blood. These studies failed to confirm the reported passage of antibodies into the blood after ingestion of milk containing them. Also, there was no indication that milk from cows infused with E. coli could protect calves from a minimum lethal dose of the bacteria given intravenously. (AH g1-8)

4. Physical methods of fly control. These investigations were initiated to evaluate and develop equipment and physical methods for the control of flies and other livestock pests. The ultimate objective is to reduce or eliminate the use of agricultural chemicals around products designed for human consumption. This work is cooperative between Agricultural Engineering, Entomology, and Animal Husbandry Research Divisions.

Preliminary studies conducted in temporary facilities at Orlando, Florida, and at Beltsville, indicated that "Black Light" ultraviolet radiation is attractive to both house flies and face flies during twilight periods. Use of fluorescent panels behind the light sources appeared to increase attractiveness.

A successful colony of face flies has been established from wild individuals. Studies are now being conducted to determine the effect of colony illumination levels on face fly egg production, period for development, adult longevity, and adult behavioral responses. Observations were made on the behavior of face flies in the field during twilight to determine characteristics which might be useful in applying controls. Face flies were marked, released, observed, and some relocated after sunset. Test equipment and techniques are being developed to evaluate the attractiveness of visible and ultraviolet radiation to face flies, house flies, and stable flies. (AH g3-12)

5. Influences of management practices and environmental factors on adaptability. These investigations involve the determination of the effect of environmental influences, including climatic elements, on dairy cattle adaptability and the evaluation of management practices on the performance of dairy cattle in hot and humid regions. The work is cooperative with the States of Georgia, Louisiana, and Texas. Some of the studies are also in cooperation with Agricultural Engineering and Animal Disease and Parasite Research Divisions. These projects contribute to the Southern Regional Dairy Cattle Breeding Project, S-49.

(a) Summer temperature patterns in the Southern United States. To provide an estimate of the frequency of occurrence of ambient temperatures high enough to affect the physiological well-being and productive performance of dairy cattle, a study was made of summer temperature conditions in 15 Southern States. The data were obtained from the U. S. Weather Bureau. Mean daily temperatures of 75°F or above for 20 or more consecutive days were considered as the point where changes in management practices to ameliorate the effects of the climatic conditions are warranted. The number of days the mean daily temperature can be expected to equal or exceed 75°F, or 80 or above and 90°F or higher was ascertained and mapped. The results indicate a mean daily temperature of 75° or above can be expected at least 20 days throughout the entirety of the 15 States considered. The only exceptions are the immediate Pacific Coastal area and areas in the Appalachians, Ozarks, and southern Rockies. The frequency of occurrence of a 75°F mean daily temperature varies from about 185 days in the extreme southern part of Texas and southern Florida, and 160 days in the vicinity of the Arizona-California border to less than 20 days in the exception areas enumerated. Throughout the major part of the area east of the New Mexico-Texas border, there are 100 days or more during the May-October period with a mean daily temperature of 75° or above, 50 days or more with a daily mean of 80° or above, but none with 90°F or above. Areas with 20 or more mean daily temperatures of 90°F or above occurred only in the southwest corner of Arizona and the bordering area of California. The results of this study may be considered as providing a general guide to or classification of the summer climate of the southern region insofar as dry bulb temperature conditions are concerned. Indications are that there is a need for further breakdowns of specific areas as humidity, terrain, prevailing wind direction, and other factors cause wide variations in local patterns and should be considered in determining the most suitable management practices for a specific area. (AH g4-3)

(b) Seasonal forage production in Louisiana. Preliminary evidence from studies at Louisiana State University indicates climatic conditions affect forage production and management. From daily evaluations of quantity and quality of forages, it was found that on the average forages were available for grazing 352 days of the year, but quality and quantity were adequate to support good milk yields for only 133 days. Of this period, only 41 days of adequate grazing were generally available from June 1st to October 31st. Indications are that good levels of production can be maintained in the area by the use of a combination of limited grazing, green chopping and silages made from the forages harvested at the proper stage of maturity. (AH g4-3)

(c) Summer temperature conditions in relation to the productive performance of lactating Jersey cows in Southeast Georgia. Additional multiple regression analyses were made in an effort to measure the lag effect that climatic stress might have on cow performance under summer conditions. Twenty-four climatic variables consisting of daily radiation, daily hours above 80°F, daily maximum temperature, 1100 dry bulb, 1100 wet bulb, and the product of dry bulb and wet bulb at 1100 were considered in relation to milk production, feed intake, and body temperature on 0, 1, 2, and 3 days prior to the day the performance variables were obtained. With these techniques, 19.8, 25.9, and 47.7%, respectively, of the variation in milk production, feed intake and changes in body temperature could be associated with the climatic variations during the 4-day period. Of those variables studied, hours above 80°F on the third day prior to performance accounted for the major part of the variation in milk production. Maximum temperature on the day performance was observed had the greatest influence on feed intake. Hours above 80° on the day of performance had the greatest influence on rectal temperature. The degree of association between dairy cattle performance and fluctuations in climate was not greatly improved by including climatic information obtained prior to the day of performance. (AH g4-3)

(d) Roof materials for summer shades in Louisiana. At Louisiana State University studies were made during the summer of 1962 of roof temperatures and radiation load under various roof materials and their relation to some physiological responses of Holstein cows. Roof temperatures and radiation loads were lowest when metal roofing was painted with a white plastic paint (Plasticool). The painted roofs were 14.1 and 25.1°F lower than aluminum and galvanized iron roofs. Radiation loads under the shaded areas were 50 to 56% lower than for unshaded areas. Although there were differences in radiation loads under the various shades, these were not reflected in significant differences in animal responses. Cattle maintained under tree or artificial shades showed significantly lower respiration rates and skin and rectal temperatures than cattle without shade. (AH g4-3)

(e) Impact of anaplasmosis in a dairy herd. There was a serious outbreak of anaplasmosis in the dairy herd at the Iberia Livestock Experiment Station, Jeanerette, Louisiana, in 1956 following the introduction of susceptible cattle from other stations. Since there are no effective vaccines, the removal of all reactors in the herd would have been a possible solution to the outbreak, but the close proximity of other herds and the loss of irreplacable genetic material from the breeding experiment made this impractical. Therefore, efforts were made to minimize the infection through vector control and treatment of clinical cases. In the seven year period, 1956-62, there were 32 clinical cases of anaplasmosis in the herd, 9 of which died and the remainder recovered. In this same period there were 55 sub-clinical cases. Although the major portion of the clinical cases recovered, the disease had a significant effect on production. Those cows which came down with clinical cases during lactation produced 26% less milk and 31% less milk fat than expected for that lactation period. There was also some carry over effect into subsequent lactations as those animals that had clinical attacks averaged 7% lower in milk yield than their contemporary herdmates. These animals also

left the herd approximately 1 year earlier than their contemporaries. The evidence thus far does not indicate the "carrier state" (as judged by reaction to a complement fixation test) is a serious detriment to production, although the negative animals had slightly higher lactation yields than those showing a reaction to the complement fixation test. Experiences in the Iberia Station herd show that if susceptible cattle are to be introduced into anaplasmosis areas they should be under 2 years of age and brought in during the "off vector season". Since the evidence points to the desirability of having an anaplasmosis free herd, the trend of infection in cows and heifers was appraised. In both groups the proportion of reactors increased up until 1959 but declined thereafter in the heifers and to some extent in the cows. Although the animals entering the lactating herd for the first time were largely negative, the cows constituted a continuing reservior of infection. From December 1956 to November 1961, 126 heifers calved for the first time. Twenty of these were reactors at the time of calving and 47 became reactors after entering the milking herd. Of the latter group, 27 became reactors within six months and the remaining 20 became reactors within 2 years after entering the milking herd. An encouraging aspect is that 50 remained negative for at least one year after first calving. Indications are that it may be possible to develop a negative herd eventually, although this remains to be fully determined. (AH g4-3)

(f) Factors affecting milk composition in two Jersey herds. Preliminary analysis of 722 complete lactations for percent fat and solids-not-fat data from Jersey cows in herds at Tifton and Reidsville, Georgia, was studied. The major portion of the variance for fat percent and solids-not-fat percent was attributable to lactation number, length of lactation, and level of milk production. Gross estimates for the variance in fat percent and solids-not-fat percent were 0.493% and 0.170%, respectively. Adjusting for lactation number, lactation length and level of milk production resulted in variance estimates of 0.182% for fat and 0.081% for solids-not-fat. Composition of the milk produced in the Tifton herd was considerably higher in fat percent and solids-not-fat than for the Reidsville herd. The level of feeding in these two herds appears to be quite different and may account for the between herd differences noted. (AH g4-3)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Digestion and Metabolism

Derbyshire, J. C., and Murphy, R. T. 1962. Diazinon residues in treated silage and milk of cows fed powdered Diazinon. Agr. and Food Chem. 10:384-386 (AH h2-9).

Flatt, W. P., and Tabler, K. A. 1961. Formulae for computation of open circuit data processing equipment. Proc. 2nd Symposium on Energy Metabolism, Wageningen, 39-47 (AH h2-8).

Flatt, W. P., and Coppock, C. W. 1963. The fasting metabolism of dry, non-pregnant adult dairy cows. J. Dairy Sci. 46:638, Abstract (AH h2-8).

Smith, L. W., Gilliam, D. R., Van Soest, P. J., and Flatt, W. P. 1962. A rapid method for carbon analysis of feeds and excreta. J. Dairy Sci. 45:674, Abstract (AH h2-8).

Van Soest, P. J. 1963. Ruminant fat metabolism with particular reference to factors affecting low milk fat and feed efficiency. A Review. J. Dairy Sci. 46:204-216 (AH h2-6).

Van Soest, P. J. 1962. The estimation of forage protein digestibility and determination of the effects of heat-drying upon forages by means of the nitrogen content and acid-detergent fiber. J. Dairy Sci. 45:664, Abstract (AH h2-6).

Van Soest, P. J. 1963. A rapid method for the determination of fiber and lignin using detergent. Report for NE-24 Regional Project, 15 pages (AH h2-6).

Forage Evaluation and Utilization

Anonymous (Gordon, C. H., and Derbyshire, J.). 1962. Making and feeding hay-crop silage. Farmers Bulletin 2186, 1-20, USDA.

Gordon, C. H., Decker, A. M., and Wiseman, H. G. 1962. Some effects of nitrogen fertilizer, maturity, and light on the composition of orchardgrass. Agronomy Journal 54:376-378 (AH h3-3).

Gordon, C. H., Derbyshire, J. C., and Jacobson, W. C. 1963. Some effects of harvest date and nitrogen fertilization on the chemical quality and feeding value of orchardgrass silage. J. Dairy Sci. 46:630-631, Abstract (AH h3-3).

Gordon, C. H., Derbyshire, J. C., Jacobson, W. C., and Wiseman, H. G. 1963. Feeding value of low-moisture alfalfa silage from conventional silos. J. Dairy Sci. 46:411-415 (AH h3-3).

Jacobson, W. C., and Wiseman, H. G. 1963. Nitrate disappearance in silage. J. Dairy Sci. 46:617-618, Abstract (AH h3-1).

Langston, C. W., and Williams, P. P. 1962. Reduction of nitrate by streptococci. J. Bacteriology 84:603 (AH h3-2).

Wiseman, H. G., and Jacobson, W. C. 1963. The determination of nitrate in silages and forages. Mimeo distributed to chemists, no number (Ah h3-1)

Calf and Heifer Feeding

Bitman, J., Cecil, H. C., Connolly, M. R., Miller, R. W., Okamoto, M., and Wrenn, T. R. 1962. Effect of vitamin A deficiency on efflux of sodium thiocyanate from cerebrospinal fluid. J. Dairy Sci. 45:879-881 (AH h1-3).

Miller, R. W., Cecil, H., Wrenn, T. R., and Okamoto, M. 1962. Replacement and absorption of cerebrospinal fluid in normal and vitamin A deficient calves. J. Dairy Sci. 45:679, Abstract (AH h1-3).

Okamoto, M., Bitman, J., Cecil, H. C., Connolly, M. R., Miller, R. W., and Wrenn, T. R. 1962. Replacement and absorption of cerebrospinal fluid and normal and vitamin A deficient calves. J. Dairy Sci. 45:882-885 (AH h1-3).

Okamoto, M., Bitman, J., Connolly, M. R., and Miller, R. W. 1962. Thiocyanate disappearance rate from cerebrospinal fluid in control and vitamin A deficient calves. J. Dairy Sci. 45:679, Abstract (AH h1-3).

Waldo, D. R., Miller, R. W., and Okamoto, M. 1963. Rumen content as affected by ration and level of feed intake. J. Dairy Sci. 46:639, Abstract (AH h1-1).

Management Practices, Equipment and Facilities

Anderson, W. P. 1963. Selection of females in Wisconsin DHIA Holstein-Fresian herds. Manuscript, University of Wisconsin (AH g5-5).

Baer, S. H. 1963. Variations in tape weight of dairy cattle. M. S. Thesis, University of Wisconsin (AH g5-1).

Conlin, B. J. 1963. Evaluation of herd averages. M. S. Thesis, University of Wisconsin (AH g5-1).

Frantz, J. 1963. Variations in ease of milking in dairy cattle. Manuscript, University of Wisconsin (AH g5-1).

Gross, L. V. 1963. Dairy cattle and climate in the Southern United States. M. S. Thesis, University of Maryland Library.

Jensen, E. L. 1963. Variations in DHIA test day production. M. S. Thesis, University of Wisconsin (AH g5-1).

Kiddy, C. A., Schultze, W. D., Johnston, J. O. and Plowman, R. D. 1962. Studies on calves and humans fed milk containing antibodies. J. Animal Science 12:1025, Abstract (AH g1-8).

Schultze, W. D., Smith, J. W., Wommack, V. C. and Norcross, M. A. 1963. Observations on the efficacy of antistaphylococcal vaccination in the control of mastitis in a dairy cattle herd. J. Dairy Sci. 46:625, Abstract (AH g3-8).

AREA NO. 8: POULTRY - BREEDING

Problem. Poultry breeders have made greater use of current genetic knowledge than any other group of livestock breeders. So widely have new principles been adopted in the industry that many breeders question whether further progress is being made in improving certain traits. They believe that the useful genetic variation already may have been exhausted. Information is needed as to the relative rates of progress which will result from various breeding systems for improving such economic traits as egg and meat production traits. Furthermore, information is needed as to whether or not different systems of breeding are required at different stages of the breeding program. Knowledge is required on the heritabilities, genetic correlations and gene-environment interactions, and the consequences of selection on these parameters, in order to design the most efficient breeding systems. Information on the physiological basis for the action of certain genes would lead to a better understanding of controlling heredity for optimum performance. Also, economics of production should be improved through basic knowledge on the genetic aspects of feed utilization efficiency and of various stresses during selection.

USDA PROGRAM

This is a continuing long-term program involving basic and applied studies of the inheritance of egg production and broiler characteristics. Scientists with majors in genetics or biochemistry and minors in physiology or statistics are involved. Much of the research is conducted within the framework of four regional projects. In addition to financial aid to several of the State contributing projects and major contributions to the establishment and maintenance of central facilities, the USDA also provides coordinating personnel located at Athens, Georgia; Lafayette, Indiana; and Beltsville, Maryland. The close working relationship between the USDA and State experiment stations in the four regional projects provides for integrated research on a large scale without duplication of effort. Research at Beltsville, Maryland, involves the selection of lines under stress of nutritional deficiency and for differences in feed utilization efficiency, including a study of genetic, chemical and physiological differences between these lines. Selection for response in egg production to "18-hour" days is conducted in cooperation with AERD. Research in the North Central region is on egg production traits and is done at the Regional Poultry Breeding Laboratory, Lafayette, Indiana, and at 12 cooperating State experiment stations. In the Southern region the major emphasis is on broiler traits and the work is conducted at the Southern Regional Poultry Genetics Laboratory, Athens, Georgia, and at 14 cooperating State experiment stations. The work in the northeastern region involves the improvement of chickens through genetic and physiological studies and is conducted under cooperative projects at 11 cooperating State experiment stations. Cooperative work on turkeys is carried on with six Western States.

A Research and Marketing Act contract with Purdue University Agricultural Experiment Station provides for a study of the genetic statistics of inbred lines of poultry and their combination in single crosses, four-way crosses, and top-crosses. This two-year study utilizes data accumulated from the North Central Regional Poultry Breeding Project and will be completed in 1964.

A grant to the Animal and Poultry Breeding Department, Ministry of Agriculture, Dekki, Giza, Egyptian Region, U. A. R., provides for a study of improving and evaluating Fayoumi and Dandarawi fowls. Its duration is for four years, 1963-1968, and involves PL-480 funds with a $131,110 equivalent in Egyptian pounds. (F4-AH-1)

During the past 12 months one line project was terminated and two new ones were initiated. In addition, the P. L. 480 project mentioned above was initiated during this reporting period.

A total of 7.4 professional Federal man-years is devoted to this program annually. Of this number 3.6 man-years are devoted to genetics and interrelations of performance traits, 3.4 to selection and systems of breeding and 0.4 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits.

1. Genetics aspects of nutritional deficiencies. Selection for fast and slow growth on both a methionine deficient and on a normal diet indicates that lines differing in growth rate can be developed under each environment. Positive and negative genetic change has been made under each environment when compared with the randombred controls. The deficient diet restricted growth so that at 3 weeks of age chicks weighed only approximately one-half that of chicks on a normal diet. The chicks from these four selected lines and the randombred controls are being used for basic biochemical studies. (AH e1-48)

2. Genetic aspects of feed utilization. Preliminary studies were conducted with inbred lines of Rhode Island Red and White Leghorn chickens to evaluate feed utilization efficiency. Analysis of data resulting from the individual feeding of laying hens indicates that some lines fairly consistently required less feed than expected, based on body weight, change in body weight, and egg mass produced. Similarly, some lines fairly consistently required more feed than expected, using the same traits and calculations. (AH e1-49)

3. Selection for egg production under sub-circadian periodicities. A study of avian reproduction under 18-hour "short days" was initiated to investigate the response, and measure the genetic progress in egg production that can be obtained by a selection program under such a regime.

Differences in production traits between the 18-hour and control populations, although small, were significant. Body weights were higher for the control birds at all observation periods, while hen-housed egg production was superior for the 18-hour population. Average age at first egg was found to be 174 days for the 18-hour birds as opposed to 170 days for the controls. Differences were significant at the five percent level for 20-week body weight, at the ten percent level for hen-housed egg production and at $P<.001$ level for age at first egg, 8 week body weight, and 320 day body weight. Analysis of egg shell data indicated high genetic correlations between percent shell, shell thickness and specific gravity. A regression analysis indicated that a third degree polynomial curve provides the best fit to the relationship between specific gravity and shell thickness. (AH e1-47)

4. Gene-environment interactions. Gene-environment interaction studies with both egg and meat production stocks were conducted in connection with the Southern Regional Poultry Breeding Project. Data indicated that the performance of egg production stocks is influenced by interactions between genotype and the environment. Two trials were conducted, each with ten egg production type stocks reared and maintained at each of ten State experiment station locations. Hatching eggs from nine commercial sources and from a randombred control population were hatched at one location and a uniform sample of chicks from each stock was shipped to each test location. Data were obtained for body weight at 8, 18 and 58 weeks of age, sexual maturity (age at first egg), 10-month egg production, egg weight, egg quality and mortality. Highly significant differences (1% level) among sources of stock and test locations were noted for body weight, egg production and sexual maturity. Highly significant differences (1% level) were observed also between the two trials for 8- and 58-week body weights and sexual maturity. For sexual maturity the interactions of source of stock x trial and source of stock x test location were highly significant (1% level). For 18- and 58-week body weights and egg production the source of stock x test location interactions were found to be significant (5% level). All second order interactions between body weight, sexual maturity and egg production were non-significant. (AH e1-44)

Ten stocks at the Texas Station were housed in 12-inch laying cages. The pullets were housed with either one or two birds per cage. Results from the study indicate highly significant differences in 18-week body weights between stocks but with no difference due to number per cage or stock x cage interaction. This same result was observed at 58 weeks. Placing two birds per cage significantly reduced age at sexual maturity and the stock x cage interaction was highly significant, accounting for 13.71% of the total variance in sexual maturity. Significant stock x cage and stock x period interactions were observed for egg production. These data indicate that certain stocks lay fewer eggs when two birds are placed in one cage. The number of birds per cage did not influence livability or feed consumption per pullet. (AH e1-44)

5. Genetic variation in economic traits. Body conformation measurements on broiler type birds were evaluated at the Arkansas Station. Four workers took two repeated measurements of shank length, keel length, body depth, and breast angle on each bird in two groups of 50 White Wyandotte broilers at 10 weeks of age. One group was from the High-Low line and the other groups from the Low line of the Arkansas Station Wyandottes. The birds were subsequently dressed and eviscerated, and the same workers took two measurements of breast angle and keel length on the dressed carcasses. Repeatability estimates for the various traits and workers were computed. Based on these repeatability estimates the relative accuracy with which the traits were measured ranked in the following descending order for the live birds: shank length, keel length, body depth, and breast angle. More accuracy can be obtained in measuring keel length and breast angle on the dressed carcass than on the live bird. (AH e1-44)

Selection at eight weeks of age for high and low body weights by Virginia workers indicated that the lines are continuing to diverge after four generations of selection. Selection for body weight at 8 weeks of age resulted in concomitant changes in body weight at other ages. There were also associated positive responses in semen volume, egg weight and Haugh units to selection for 8-week weight, whereas the relationship was negative with age at sexual maturity and percentage egg production. Correlated responses of unselected traits to selection for breast angle at 8 weeks were less dramatic. There was positive and significant association between the selected trait, breast angle, and each of the correlated traits, body weight and egg weight. Differences between the lines were not significant for semen volume, sexual maturity, egg production or Haugh units. (AH e1-44)

Following the fifth generation of selection for single traits, lines for high egg production, large body weight, small body weight, high egg weight and low egg weight lines have been evaluated at Iowa. The large body weight line produced eggs larger in weight but slightly fewer in number than the small body weight line. The high egg weight line also laid somewhat fewer eggs and had larger body weight than the low egg weight line. Leghorns selected for two traits, large body weight and low egg weight, laid at the same rate as those in the line selected for small body weight and high egg weight. However, progress in the two selected traits in each line was positive, indicating that large body weight and small egg size are not seriously antagonistic and can be attained in the same individual. (AH e1-43)

Investigations concerning altitude stress revealed that slightly better hatchability was obtained from the higher elevation line (9,100 ft. vs. 7,200 ft.) of Broad Breasted Bronze turkeys when eggs from both lines were set at either the 9,100 ft. or 7,200 ft. elevation locations. Hatchability decreased when the pre-incubation storage period was extended from a 1-7 day holding period to 8-14 and 15-21 days. (AH e1-46)

Contrary to results of previous years, the higher elevation line of Broad Breasted White turkeys (7,200 ft. vs. 4,300 ft.) had somewhat lower

hatchability when eggs from both lines were set at either the 7,200 ft. or 4,300 ft. locations. (AH e1-46)

6. Genetic variation in chemical or physiological traits. Birds in the line selected at the Maryland Station for high serum cholesterol level had a higher adult serum cholesterol level, slightly lower body weight and higher albumen quality than those in the line selected for a low serum cholesterol level. Differences in production have been small and inconsistent for the two lines. Studies with radioactive (C^{14}) cholesterol suggest that the differences between the two lines are due to a greater excretion of cholesterol by the low line. (AH e1-45)

Selection studies for high and low blood pressure indicate that in the fifth generation differences between the two lines were greater than in any previous generation. Mortality in both lines was low with no significant difference in male progeny but an appreciably lower mortality in the hypertension (high line) females. (AH e1-45)

A study of the genetic and physiological significance of the red cell antigens in chicks at the Texas Station indicated that survival rate is increased in birds having the B^7 allele as a part of their genotype. The advantage in adult livability was more pronounced in the heterozygous females than among the males from the same inbred line. The effect of blood group genotype upon skin graft survival was studied by the Texas workers in their inbred line number 22. The results of the study indicate that no successful grafts could be made where the donor and recipient had incompatible B blood group genotypes. The D and E systems apparently are more compatible and some successful grafts were obtained. Selection was started to develop lines with high and low homograph survival. (AH e1-44)

B. Selection and Systems of Breeding

1. Evaluation of genetic changes produced by various breeding systems. Forty-four samples consisting of various breeding systems under study in the North Central region, their controls and certain crosses between them were compared at the Regional Poultry Breeding Laboratory, Lafayette, Indiana. Twelve of the fifteen selection systems were superior to the Regional Cornell control stock in final percent hen-day egg production. One generation of selection on the Purdue Pool population was ineffective in increasing egg production; however, progeny of the Regional Cornell X Purdue Pool and reciprocal cross were significantly improved over the Purdue Pool parent. (AH e1-43)

Breeding systems were evaluated at five Stations in addition to the North Central Regional Poultry Breeding Laboratory. At each location the same foundation stock and controls were used. At each Station single-trait selection for hen-day percent egg production from first egg to about 300 days of age was used. Other traits were recorded but not used for selection.

Selection pressure was maintained at approximately 25 percent for both male and female progeny. Results to date are reported below.

At Purdue, closed flock and reciprocal recurrent selection in Cornell and Purdue Pool populations were compared. In addition, crossbreds of the two control populations were used for closed flock selection. Data indicate that differences exist between the original strains used and the crosses between them. Furthermore, the significant differences noted between the lines are still a reflection of differences between original lines, and after one generation of selection the selected lines are not significantly different from the controls.

At the Kansas Station, family index and reciprocal recurrent selection were the breeding systems studied. Results indicate that after the first generation of selection, seven of nine selected groups had a higher percent hen-day egg production to 500 days of age than the respective controls. Comparisons of hen-day egg production to 260 days of age and 500 days of age for two generations of selection indicate family selection to have resulted in an increase in egg production, the exception being in the within cross family selection group. Recurrent selection lines in this group indicate a lowering of percent egg production and no consistency on a within year control comparison. Other observed but unselected traits showed little or no change from the controls.

The Missouri Station has completed three generations of selection for higher rates of production by both the recurrent selection method and the family selection method. There was no apparent difference in livability which could be related to type of breeding. Data indicate that selection for egg numbers is progressing much faster with the R.I.R. line than with the W.R. line.

At the South Dakota Station various methods of inbreeding are being studied. Twelve inbred lines from the Regional Cornell stock reached inbreeding coefficients of approximately 50% in 1961. Six lines were from selected stock; six were randomly developed. There appeared to be little difference in the performance of pullets from matings of either selected or random inbred males mated to non-inbreds. Traits observed were maturity, hen-day production, egg size and adult body weight. Very little broodiness but relatively high mortality was observed in both groups.

Four generations of sire family selection on the Regional Cornell stock at the North Central Regional Poultry Breeding Laboratory have produced a significant difference in egg production between the restricted inbreeding and inbreeding phases of the system. Dam family selection for three generations on the same base population shows steady improvement in egg production while two generations of individual selection produced no change. (AH e1-43)

2. Randombred control populations. Six randombred populations are maintained for use as genetic and environmental controls and as a gene pool for use in initiating new research. Four stocks are maintained at Lafayette, Indiana, primarily for egg production research and two at Athens, Georgia, for meat production research. Hatching eggs are supplied to research workers at experiment stations, to random sample tests and to commercial poultry breeders. (AH e1-43, AH e1-44)

In a study of the stability of randombred populations, observations on ten morphological traits were recorded at the North Central Regional Poultry Breeding Laboratory over a six year period. This study indicates no significant gene frequency shift in the population studied and maintained in the manner used at the Laboratory. Furthermore, at the Minnesota Station the Regional Cornell Leghorns were maintained at two flock sizes, one consisting of 50 males and 250 females and the other of 15 males and 125 females. Results indicate no differences in hatchability, eight-week body weight or chick mortality through the fifth generation. (AH e1-43)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Genetics and Interrelations of Performance Traits

Bailey, Bernie, B., Fanguy, R. C., and Quisenberry, J. H. 1961. The effect of lethal irradiation upon subsequent blood hemotocrit, plasma volume and total blood volume of chicks. Poultry Sci. 40:1374. (AH e1-44)

Bailey, Bernie B., Fanguy, R. C., and Quisenberry, J. H. 1961. A comparison of effects of continuous and discontinuous x-irradiation upon the mortality of different age chicks. Poultry Sci. 40:1375. (AH e1-44)

Bailey, Bernie B. 1962. The relation of blood group genotypes to the effectiveness of bone marrow transplants in lethally x-irradiated chicks. Ph.D. dissertation, A. and M. College of Texas. (AH e1-44)

Brown, R. V. 1962. Sex differences in hemagglutination response. Immunogenetics Newsletter. 2:8, 115-116. (AH e1-43)

Brown, R. V. 1962. Blood group studies in five lines of White Leghorns selected for single quantitative traits. Ph.D. Thesis on file, Iowa State University Library. (AH e1-43)

Brown, R. V. and Nordskog, A. W. 1962. Correlated responses in blood group gene frequencies with selection for body weight and egg weight in the fowl. Records of the Genetics Soc. of Am. 31:76. Abstract. (AH e1-43)

Champion, L. R., Zindel, H. C. and Esmay, M. L. 1962. Poultry science research at the Upper Peninsula Experiment Station, Chatham, Michigan. IV. Population density as related to laying house performance in four experimental laying houses. Mich. Agr. Expt. Sta. Quart. Bul. 45(8):67-83. (AH e1-43)

Cook, R. E., Hess, C. W., Carmon, J. L. and Dembnicki, E. F. 1962. Importance of genotype-environment interactions at various ages in broiler type chickens. Poultry Sci. 41:1637. Abstract. (AH e1-44)

David, Chelladurai S. 1962. The heritability of rate of oxygen consumption in the domestic fowl. M.S. thesis, University of Kentucky. (AH e1-44)

Dolyak, Frank. 1962. Intraspecific variations among chicken plasmas. Taxonomic Biochemistry, Physiology and Serology, Ronald Press, N. Y., edited by Charles A. Leone. (AH e1-45)

Edwards, W. S., Blow, W. L. and Barber, C. W. 1961. Response of four-way crosses of White Leghorns to inoculation with avian leukosis complex strain RPL-12. Poultry Sci. 41:1642. Abstract. (AH e1-44)

Eisen, E. J., Bohren, B. B. and McKean, H. E. 1962. The Haugh Unit as a measure of egg albumen quality. Poul. Sci. 41:1461-1468. (AH e1-43)

Eisen, E. J. and Bohren, B. B. 1962. Some problems in the evaluation of egg albumen quality. Poultry Sci. 42:74-83. (AH e1-43)

Fanguy, Roy C. 1961. Blood typing techniques in chickens. Texas Agri. Expt. Sta. Bul. MP-551. (AH e1-44)

Fanguy, R. C., Bailey, B. B. and Quisenberry, J. H. 1961. Therapeutic effects of hematopoietic tissue transplants in lethally irradiated chicks. Poultry Sci. 40:1400. Abstract. (AH e1-44)

Friars, G. W., Bohren, B. B. and McKean, H. E. 1961. Time trends in estimates of heritabilities, genetic environmental and phenotypic correlations of certain traits of a population of chickens subjected to multiple objective selection. Poultry Sci. 40:1404. Abstract. (AH e1-43)

Friars, G. W., Bohren, B. B. and McKean, H. E. 1962. Time trends in estimates of genetic parameters in a population of chicken subjected to multiple objective selection. Poultry Sci. 41:1773-1784. (AH e1-43)

Giesbrecht, F. and Nordskog, A. W. 1962. Estimating age at sexual maturity from flock records. Poultry Sci. 42:83-87. (AH e1-43)

Hardy, L. B. Auger, H. V. and Wilcox, F. H. 1962. Genetic differences in cholesterol in chickens. Am. J. Physiol. 202:997-1001. (AH e1-45)

Harper, J. A. and Parker, J. E. 1962. Effect of fall hatch date and length of light restriction on the photoperiodic response of turkey females. Poultry Sci. 41:493-497. (AH e1-46)

Hess, C. W., Edwards, H. M., Dembnicki, E. F. 1962. Growth-rate selection on a methionine deficient diet. Poultry sci. 41:1042-1047. (AH e1-44)

Hyre, H. M., Cunningham, C. J., Dunbar, Jr. R. S. and Clark, T. B. 1962. Breeding for efficient production of eggs and poultry meat. W. Va. Univ. Agr. Exp. Sta. Bull. 479. (AH e1-45)

Jaap, R. G., Smith, J. H. and Goodman, B. L. 1962. A genetic analysis of growth and egg production in meat-type chickens. Poultry Sci. 41:1439-1446. (AH e1-43)

Kidwell, Margaret Gale and Nordskog, A. W. 1962. Linear versus Haugh unit method of correcting albumen weight for egg weight. Poultry Sci. 41:1655. Abstract. (AH e1-43)

Kinder, Q. B. and Stephenson, A. B. 1962. Floor space studies using slat floor and litter floor for laying hens. Poultry Sci. 41:1394-1400. (AH e1-43)

Lowe, P. C., Carson, J. R. and King, S. C. 1962. Blood transfusions and the heredity of plumage color in chickens. J. Heredity 54:17-22. (AH e1-43)

Morgan, Walter and Kohlmeyer, William. 1961. Transmissibility of double oviducts in Aves. Genetics 46:884. (AH e1-43)

Morgan, Walter. 1962. Avian cerebral hernia. Proc. S. D. Acad. Sci. 41:119. (AH e1-43)

Morgan, Walter and Greb, Raymond. 1962. Fragmentary resorption of the right oviduct. Proc. S.D. Acad. Sci. 41:123. (AH e1-43)

Nordskog. A. W. 1962. Linear and non-linear effects associated with percentage of blood in Rhode Island Red X Fayoumi crosses. Poultry Sci. 41:1670. Abstract. (AH e1-43)

Ogasawara, F. X., Wilson, W. O. and Asmundson, V. S. 1962. The effect of restricting light during the adolescent period on reproductive performance in turkeys subsequently exposed to a 12-, 14- and 20-hour day. Poultry Sci. 41:1858-1863. (AH e1-46)

Schierman, L. W. and Nordskog, A. W. 1962. Relationship of erythrocyte to leukocyte antigens in chickens. Science 137:620-621. (AH e1-43)

Schierman, L. W. 1962. Genetic analysis of transplantation immunity in the fowl. Ph.D. Thesis on file, Iowa State University Library. (AH e1-43)

Schierman, L. W. and Nordskog, A. W. 1962. Sampling aspects of blood testing for pullorum. Poultry Sci. 42:88-94. (AH e1-43)

Schierman, L. W. and Nordskog, A. W. 1963. Influence of the B blood group-histocompatibility locus in chickens on a graft - versus - host reaction. Nature 197:511-512. (AH e1-43)

Schweitzer, L. J. and Nordskog, A. W. 1962. The influence of parent flock source on poultry performance. Poultry Sci. 41:1578-1585. (AH e1-43)

Siegel, P. B. 1962. Protein and energy requirements of chicks selected for high and low body weight. Poultry Sci. 41:1225-1232. (AH e1-44)

Strain, J. H. and Nordskog, A. W. 1962. The relative importance of breeder flock and broiler flock factors determining income over feed costs in random sample broiler tests. Poultry Sci. 41:1573-1577. (AH e1-43)

Strain, J. H. and Nordskog, A. W. 1962. Genetic aspects of the profit equation in a broiler enterprise. Poultry Sci. 41:1892-1902. (AH e1-43)

Sturkie, P. D., Vogel, J. A. and Textor, K. 1962. Cardiovascular differences between high and low blood pressure chickens. Poultry Sci. 41: 1619-1620. (AH e1-45)

Washburn, K. W. 1962. Influence of thiouracil on various traits in divergent lines of chickens. M.S. Thesis, Virginia Polytechnic Institute. (AH e1-44)

Wilson, W. O., Ogasawara, F. X. and Asmundson, V. S. 1962. Artificial control of egg production in turkeys by photoperiods. Poultry Sci. 41: 1168-1175. (AH e1-46)

Zervas, N. P., Collins, W. M. and Skoglund, W. C. 1962. Genetic variation in yellow shank pigmentation intensity, and 8 week body weight of chickens. Poultry Sci. 41:1247-1254. (AH e1-45)

Selection and Systems of Breeding

Abplanalp, H., Ogasawara, F. X. and Asmundson, V. S. 1963. Influence of selection for body weight at different ages on growth of turkeys. British Poultry Science 4:71-82. (AH e1-46)

Bray, D. F., Bell, A. E. and King, S. C. 1962. The importance of genotype by environment interaction with reference to control populations. Genet. Res. 3:282-302. (AH e1-43)

Carson, James R. 1962. Breeding systems for the improvement of productivity in chickens. (NC-47 Publication) Purdue Univ. Press. Research Bulletin No. 754. (AH e1-43)

Hicks, Jr., A. F. 1962. Egg mass as a biological selection index. Poultry Sci. 41:1649. Abstract. (AH e1-45)

Moyer, S. E., Collins, W. M. and Skoglund, W. C. 1962. Heritability of body weight at 3 ages in crossbred broiler chickens resulting from 2 systems of breeding. Poultry Sci. 41:1374-1382. (AH e1-45)

Nordskog, A. W. and Festing, Michael. 1962. Selection and correlated responses in the fowl. Proceedings XII World's Poultry Congress (Sydney, 1962) pp. 25-29. (AH e1-43)

Siegel, P. B. 1962. Selection for body weight at eight weeks of age. I. Short term response and heritabilities. Poultry Sci. 41:954-962. (AH e1-44)

Smith, L. T. 1962. The development and use of segregating inbred lines. Ph.D. Thesis on file, Iowa State University Library. (AH e1-43)

AREA NO. 9: POULTRY - PHYSIOLOGY

Problem: Continuing basic research in avian physiology is essential to establish fundamental concepts and to increase the body of knowledge upon which ultimately must depend the resolution of many long standing issues of practical import, e. g., the "problems" of fertility, hatchability, growth and egg production. A continuing flow of basic physiological knowledge is necessary also for implementation of the subject matter of other disciplines. In some important areas, research to date has accomplished little beyond outlining the magnitude of the task at hand. In reproductive physiology, for example, the dominant role of the central nervous system is now generally recognized, but much intensive research will be required before we can expect any "useful" knowledge of mechanisms by which the varying actions of external and internal factors are integrated and directed to initiate, maintain or modify reproductive functions. Many aspects of environmental physiology, of responses to stress, and of growth and development likewise depend upon basic research for the bank of knowledge that can be applied toward useful ends. On the more immediately practical side, increased knowledge of poultry housing, related equipment and other management factors is necessary to provide optimal ranges of operational efficiency.

USDA PROGRAM

This is a continuing program, mainly on basic aspects of the physiology of avian reproduction, but including also applied studies pertaining to environmental physiology and management. In addition to physiologists, the work draws upon geneticists and animal husbandmen. Research is in progress at Beltsville, Maryland, and Glendale, Arizona, the work at Glendale contributing to regional project W-50. Cooperation currently is maintained with members of the Farm Electrification Branch, AERD, Columbia University, the National Institutes of Health, and Pennsylvania State University. Federal research in this area calls for 5.7 professional man-years, distributed to subareas as follows: Physiology of reproduction, 4.0; environmental physiology, 1.4; and program leadership, 0.3.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Neuroendocrinology. Work was continued with the hen on the effects of electrical stimulation of the hypothalamus on ovulation. As was noted in the preceding report, stimulation of two hypothalamic regions, the anterior median eminence and ventromedial preoptic area - results in the delay of ovulation of the first follicle of the hen's sequence, apparently by the temporary suppression of the release of ovulation-inducing hormone (OIH). Recent studies have shown that although delays in ovulation

following stimulation of either site are of the same magnitude, the mediation of the effect in the two sites is not the same. In the preoptic region, ovulation is delayed by stimulation with stainless steel or platinum electrodes, or by the mere insertion of electrodes without the use of current. Conversely, the median eminence region responds only to stimulation with stainless steel electrodes, a form of stimulation known to have a prolonged irritative action, due to the electrolytic discharge of metallic ions from the electrode tips. The physiological basis for the differing response in the two areas remains to be elucidated.

In examining the effects of electrical stimulation in the preoptic region on ovulation, it was discovered that brain stimulation in the hen causes premature oviposition of the terminal egg of a recurrent sequence. Further investigation revealed that the degree of premature lay was independent of the time of effective stimulation, and that nearly all premature eggs were laid between the hours of 10 A.M. and noon on the day of normal lay. It was also found that premature lay depended only on operative interference with the brain, and that this effect could not be blocked by deep anesthesia administered at the time of operation. Significantly, the premature oviposition in some hens occurred independently of any effect on ovulation of the mature ovarian follicle.

Because of the current lack of knowledge of mechanisms controlling oviposition in birds, an interpretation of the above results is impossible at this time. The findings are of immediate interest to the reproductive physiologist for at least two reasons: (1) The premature oviposition is not caused by a reflex nervous activation of the uterine musculature, but must be mediated by some complex hormonal mechanism; (2) the remarkable constancy in the time of premature lay strongly suggests that the period of premature lay is governed by diurnal periodicity in some undetermined physiological state of the hen. These facts provide a basis for a new approach to the study of neuroendocrine mechanisms controlling oviposition. (AH e3-15)

A colony of Japanese quail (Coturnix coturnix japonica) has been established at Beltsville for the purpose of making comparative studies on the control of ovarian function in birds. A continuous population of 288 adult hens, maintained in individual laying cages in a light-proof room, are being used to study the pattern of ovulation and oviposition. Others workers have established that the quail, like the chicken, lays in recurrent sequences throughout the year. Initial investigations at Beltsville were aimed at determining whether or not successive ovipositions and ovulations in a sequence occur in an association constant enough to permit estimates of the time of ovulation from past records of oviposition.

Ovulation in the quail was found to occur within some 15 to 120 minutes after the time of the preceding oviposition within a sequence. The interval from ovulation to the entrance of the egg into the uterus was found to be about 5-6 hours. The arrival of the egg into the uterus can be readily

detected by digital palpation of this organ through the ventral wall of the abdomen. Early detection of the uterine egg provides a convenient means of distinguishing between a normal ovulation, and an ovulation significantly advanced or delayed by experimental manipulations. Having established the existence of these relationships, it will now be possible to work out the sequence of crucial events in the ovulatory cycle, including the times of follicular maturation and OIH release. (AH e3-15)

2. Parthenogenetic reproduction. In parthenogenetic tests conducted in 1963 an attempt was made to get additional information on the nature and origin of cells that give rise to parthenogenetic embryos.

One point of interest was the characteristic delay exhibited by parthenogenetic cells before they start to develop once the unfertilized eggs have been placed in the incubator. To get more precise information on the degree of variability existing among parthenogenetically developing eggs the following tests were conducted: Thirteen different groups of unfertilized turkey eggs were incubated. Eggs comprising each group were candled after 24 hours, thereafter for the first seven days of incubation. At each candling, eggs in which development could be detected were identified. Eggs not exhibiting development at 24 hours of incubation were recandled at 48 hours and daily thereafter through the seventh day of incubation. All eggs were broken and classified on the 10th day of incubation. Data collected on unfertilized eggs were compared with similar data obtained by candling fertilized turkey eggs. Results of these tests show that less than 8 percent of the parthenogenetically developing embryos could be detected by candling at 24 hours of incubation. Thirty-one percent could be detected after 48 hours and 69 percent after 72 hours. This is in contrast to fertilized eggs in which 96.5% of all embryos could be detected after 24 hours of incubation. This characteristic lag in the onset of development on the part of parthenogenetically developing embryos, plus the fact that most parthenogenetic poults hatch on the 29th or 30th day of incubation, shows that rate of development, once the parthenogenetic cells have become organized, is as rapid as normal cells. The 2-3 day lag in time required for the initiation of development gives some added support for the belief that parthenogenetic embryos arise from isolated cells derived from the multicellular germinal disc. The lag probably represents the time required for isolated cells to multiply and organize into embryos after the eggs are placed in the incubator.

If parthenogenetic embryos are arising from isolated cells, as is postulated, it is conceivable that some treatment could be administered to eggs during critical stages in embryo formation which would be reflected in the level of parthenogenetic development. Such an approach was attempted. Various groups of incubating eggs were subjected to marked fluctuations in temperature on critical days of incubation. Eggs were first immersed for 20 minutes in water at 116-120°F. They were then quickly removed and immersed for 20 minutes in water maintained at 46°F. Groups of unfertilized eggs received this treatment after having been incubated 1, 2, 3, and

4 days. Other groups of eggs serving as controls were not dipped. The rapid temperature change apparently caused no material change in the overall level of parthenogenetic development. Thirty-seven to 48 percent of all eggs dipped, upon return to the incubator, underwent parthenogenetic development. In four groups of controls, development varied from 34 percent to 42 percent. It should be noted, however, that following dipping a higher percentage of embryos were encountered in each of five lots of eggs. More than 15 percent of the unfertilized eggs dipped on the third and fourth day of incubation contained well-formed embryos. Slightly less than eight percent of the undipped eggs serving as controls contained embryos.

In a second series of dipping experiments two antibiotics, penicillium and streptomycin, were added to the cold water bath (500,000 units of penicillium and one gram of streptomycin in 5000 ml. of water). Contraction of the egg contents when eggs were transferred from hot to cold water caused a limited amount of the two antibiotics to be drawn within the egg. Six groups of eggs were involved in these tests, three of which were dipped in cold water containing the two antibiotics and three in cold water without antibiotics. One group of treated eggs, along with its corresponding control, was dipped on the first day of incubation, others on the second and third days of incubation. Four additional groups of eggs were retained in the incubator to serve as untreated controls. In each of the three tests in which antibiotics were employed, a lower incidence of parthenogenetic embryos was encountered: 5.2%, 5.7%, and 8.8% as compared to 10.5%, 10.6%, and 15.6%, respectively, for dipped controls. Corresponding values for the four untreated controls were: 6.3%, 7.1%, 10.0%, and 7.8%, respectively. It would appear, therefore, that the presence of either of the two antibiotics in the cold water tended to reduce the percentage incidence of embryos.

The ability of virgin chicken or turkey hens to produce eggs which will develop parthenogenetically is largely dependent on their genetic constitution. The sire as well as the dam transmit factors to their offspring which are associated with the expression or non-expression of parthenogenetic development. This fact came to light when six cross-bred females whose eggs showed a marked tendency toward parthenogenesis (32.8%) were mated first to Dark Cornish males and subsequently to White Leghorn males. The Dark Cornish males came from a strain of birds showing a pronounced tendency toward parthenogenesis while the White Leghorn males were from a line showing no parthenogenesis.

Thirty-nine backcross virgin females, sired by Dark Cornish males, laid a total of 1201 eggs, of which 134 or 11.2% upon being incubated underwent a limited degree of parthenogenetic development. Thirteen backcross virgin females of the same dams, but sired by White Leghorns, produced 473 eggs, of which only one (0.2%) underwent parthenogenetic development. Thus, the incidence of parthenogenesis in eggs of the progeny of the same hens was 55 times greater when the Dark Cornish rather than White Leghorns served as sires.

A study of the chromosomes of interfamilial hybrids of Dark Cornish chickens and Beltsville Small White turkeys has contributed good evidence that they are true diploid hybrids. Fourteen to fifteen macrochromosomes, with a numerical range of from 6 to 20, were found in the majority of hybrid cells. This number is intermediate between the macrochromosome numbers of 18 for turkeys and 12 for chickens. The hybrid macrochromosomes exhibited no variations in number or behavior which differed from those of normal chickens and turkeys. The lack of identifying characteristics on the chromosomes rendered it impossible to distinguish the parental genomes in the hybrid cells. (AH e3-19)

3. Homograft tolerance. In continuation of a cooperative project with Drs. William V. Healey and Paul S. Russell of Columbia University, College of Physicians and Surgeons, a series of second set wattle skin homografts were transplanted from parthenogenetic Beltsville Small White turkey sires to their surviving progeny by unrelated turkey females. These progeny had received first set skin homografts at least 14 weeks previously. Those progeny which had rejected first set grafts also rejected second set grafts while the one progeny which had accepted the first set graft also accepted the second set graft. Subsequently, a second experiment was performed in which two of the parthenogens in the above experiment donated grafts to two more male and two more female progeny each by unrelated females. Seven of these progeny rejected first and second set grafts in typical first and second set homograft reactions. The eighth recipient has permanently accepted both first and second set grafts. The second set grafts in the second experiment, transplanted only 14 days after rejection of the first set, were promptly rejected as ischaemic, mummified grafts. To our knowledge this is the first report in birds of a second set rejection analogous to the second set "white graft" reaction in mammals, and it is taken as good evidence for a high degree of active transplantation immunity having been acquired by the progeny in response to the first set grafts. All of these results are in complete agreement with the preliminary results and conclusions of the first experiment set forth in last year's report, i.e., that histocompatibility antigens can be present in parthenogenetic sires which are not present in their progeny and therefore parthenogens apparently can be heterozygous at the genetic loci which are assumed to control expression of histocompatibility antigens. (AH e3-20)

B. Environmental Physiology

1. Controlled photoperiods in turkeys. Light restriction by short days and by low intensity during the late growing period was shown to be markedly successful in preconditioning out-of-season turkey females for subsequent reproduction (1962 report). Since both of these methods require blackout facilities, a preliminary experiment was conducted to test the effectiveness of a light preconditioning method that did not require blackout. The method consisted of brooding the turkeys of both sexes for 9 weeks under 24-hour continuous light, then gradually shortening the daily photoperiod of the females to that provided by nature at

the time the birds were 28 weeks of age, which amounted to 14 hours 35 minutes between sunrise and sunset on May 25, 1962. At 29 weeks a stimulatory photoperiod of 17 hours was applied abruptly and was gradually increased to reach 24 hours by September 14; this was continued to the end of the experiment on November 13. A control group of females and males were brooded to 9 weeks under 24 hours of light, then reared to 29 weeks of age under natural light conditions, which involved increasing light days during the growing period prior to production. Differences in reproductive results indicated that the gradual shortening of the daily photoperiod during the growing period caused sexual maturity to be dealyed 28 days and egg production for the period ending November 13 to be 17 eggs less than that of the controls, 78 eggs versus 95 eggs. Fertility and hatchability of fertile eggs, however, were higher in the treated birds and resulted in a calculated average of 53 poults versus 43 for the controls. Although the overall reproductive performance of the turkeys under decreasing photoperiods was better than that of the controls, it cannot be said the method of preconditioning tested in this experiment was successful. (AH e3-18)

2. New turkey cage floor. An improved type of cage floor, designed to reduce egg breakage, was developed for use in turkey laying cages. The floor was constructed of flattened metal strips of flexible wire. The entire floor was then covered with plastic. Egg breakage following installation of this improved floor was reduced from a level of about 10% to less than one percent. Besides reducing egg breakage, use of these floors enjoys the added advantage of being easier on the birds' feet. The flat, closely spaced wires provide more surface area and this tends to reduce the incidence of calloused feet. (AH e3-19).

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Physiology of Reproduction

Healey, W. V., Russell, P. S., Poole, H. K., and Olsen, M. W. 1962. A skin grafting analysis of fowl parthenogens: Evidence for a new type of genetic histocompatibility. Ann. N. Y. Acad, Sci., 99, 698-705. (AH e3-20)

Olsen, M. W. 1962. Polyembryony in unfertilized turkey eggs. J. Hered., 53, 125-128. (AH e3-19)

Opel, H. 1961. Delay in ovulation in the hen following stimulation of the preoptic brain. Proc. Soc. Exp. Biol. and Med., 113, 488-492. (AH e3-15)

Poole, H. K., Healey, W. V., Russell, P. S., and Olsen, M. W. 1961. Evidence of heterozygosity in parthenogenetic turkeys from homograft responses. Proc. Soc. Exp. Biol. and Med., 113, 503-505. (AH e3-20)

Environmental Physiology

Marsden, S. J., Cowan, N. S., and Lucas, L. M. 1962. Effect of gradual and abrupt lengthening of photoperiod on reproductive response in turkeys. Poultry Sci., 41, 1864-1868. (AH e3-18)

Olsen, M. W. 1963. Special floor reduces egg breakage in turkey laying cages. Poultry Sci., 42, 43-45. (AH e3-19)

AREA NO. 10: POULTRY - NUTRITION

Problem. The goal of nutrition research is to amass information so that poultry diets may be formulated and fed to produce the best quality product at the least possible cost. The problem logically divides into two areas: (1) furnishing the nutritive requirements of poultry, and (2) the feedstuffs that supply these requirements. A refined methodology is needed to estimate more accurately the energy (carbohydrates and fats), protein (amino acids), vitamin and mineral requirements of poultry of various ages, strains and level of production. But, even more urgently needed is information on the relationships that exist between these nutrients, if the formulation of optimum nutritive balance in diets is ever to be attained. Additional information is required on the effect of feed additives (antibiotics, arsenicals, hormones, enzymes, antioxidants, tranquilizers) on nutritive requirements, and on the utilization of protein and energy. Somewhere in the maze of requirements, interrelationships and interactions, it must be determined which portion of the diet is for intestinal microorganisms and which is for the host. Also, the vast field of interrelationships between disease and nutrition remains to be explored. In the feedstuffs area, how much of a particular nutrient that is present should be known, but of more importance is how much is available to the bird. Thus, information on digestibility, absorption, chelation and interactions is necessary. In addition, the complete composition of a feedstuff must be known. At the present, the proximate analysis is the only information available about major dietary constituents, consequently, the nutritionist does not know exactly what is being fed when a diet is formulated. There may be present growth promotant and/or inhibitors of which he is not aware.

USDA PROGRAM

This is a continuing program conducted by nutritionists on basic and applied research on the nutritive requirements and digestion and metabolism of poultry and the nutritive value of feedstuffs. The work is in progress at Beltsville, Maryland, and at the Southwest Poultry Experiment Station, Glendale, Arizona. Some phases of work at Glendale are carried on in cooperation with the Departments of Biochemistry and Poultry Science of the University of Arizona at Tucson. Studies concerned with the influence of different factors on the metabolism of vitamin A in chickens are in progress at the Hebrew University, Rehovoth, Israel. Its duration is for three years, 1962-1965, and involves PL.480 funds with $29,527 equivalent in Israeli pounds. (A10-AH-7)

The Federal effort devoted to research in the poultry nutrition area totals 8.0 professional man years. Of this number 3.7 are devoted to nutritive requirements, 2.0 to digestion and metabolism, 1.9 to the nutritive values of feedstuffs, and 0.4 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Nutritive Requirements

1. Fat requirements. The performance of 3 groups of pullets--group 1 fed a fat-free diet, group 2 fed the fat-free diet plus lard, group 3 fed a standard laying diet--was observed for a 40-week period. This dietary treatment resulted in a partial unsaturated fatty acid depletion in groups 1 and 2.

The egg production of groups 1 and 2 was essentially equal and was considerably lower than that of group 3. The eggs laid by groups 2 and 3 were heavier than those of group 1 and the hatchability was also poorer in group 1. By the end of the experimental period, the time required for the hatching of the eggs of group 1 was prolonged about 36 hours beyond the usual hatching time. The major changes in the fatty acid composition of tissues resulting from the dietary treatments of groups 1 and 2 were an increase in the monosaturated fatty acids, oleic and palmitoleic, and a decrease in the polyunsaturated linoleic and arachidonic acids. There were no consistent changes in the fatty acid composition of the tissues of the pullets of groups 3. (AH e2-13)

Studies at Glendale, in cooperation with the University of Arizona, concerned with the effect of varying amounts of energy in laying diets, indicated that energy levels varying from 1150 to 1550 Cal/lb. of metabolizable energy had no effect on egg production. The efficiency of feed utilization increased progressively as the caloric content of the diet increased. The energy level in the diet had no effect on hatchability, and little effect on egg weight. Mortality was least on the lowest energy level and greatest on the highest level. (AH e2-15)

2. Protein and amino acid requirements. Studies with varying protein levels in growing and laying diets were continued using three commercial strains of White Leghorn chickens. Protein levels in the growing diets of 21 percent to 8 weeks of age, followed by 16 percent to 21 weeks, or 16 percent throughout the growing period, gave about the same growth and feed conversion, which was superior to that obtained with 16 percent protein to 8 weeks followed by 12 percent. When pullets from each of the growing diets were placed on 12, 14, 16, or 18 percent protein laying diets, the group which had received the 16 and 12 percent protein growing diet, and 12 percent protein laying diet, gave the poorest performance. The groups receiving the 14 percent protein laying diet produced as well as those on the 16 or 18 percent levels, regardless of growing treatment. The hens on the 12 percent protein laying diet produced smaller eggs than those of the higher protein levels. There was a strain difference in protein requirement for egg production. This phase of investigation is completed and future work will be concerned solely with amino acid requirements.

Preliminary studies concerned with supplementation of low protein diets with certain amino acids showed that when a 12 percent protein laying diet was supplemented with methione, lysine and tryptophan, there was an increase in production. Addition of the amino acid mixture to a 14-percent protein diet did not improve production. The amino acids did not affect egg size. (AH e2-16)

Studies at Glendale, in cooperation with the University of Arizona, showed the methionine supplementation of laying diets containing 1350, or 1450 calories of metabolizable energy per pound, had no effect on performance, whereas supplementation of a higher energy diet (1550C/ME/lb.) resulted in a slight improvement in egg production and feed converstion. The methionine-analong had no effect on egg size, hatchability, or mortality. Under the condition of the experiment 0.41-0.44 percent of methionine, plus cystine, appeared to be adequate for egg production. (AH e2-15)

3. Mineral requirements. In continuation of the study of calcium and phosphorus requirements of broiler chicks, a third test was conducted. This trial was with mixed sexes, and involved calcium levels of 0.7, 0.75, 0.80, and 0.85 percent, and total phosphorus levels of 0.45, 0.50, 0.55, 0.60, and 0.65 percent. Preliminary examination of the data indicated from 0-8 weeks a highly significant response to calcium, significant responses to phosphorus, calcium x phosphorus, and calcium x sex. At 4 weeks of age bone ash showed highly significant response to phosphorus and sex. Feed conversion was not significantly affected by any of the mineral levels at any age. The large volume of data from this trial is in the process of exhaustive statistical analysis, and it appears that a careful evaluation of the results of this and the two preceding trials will yield accurate values for the calcium and phosphorus requirements of broilers. (AH e2-18)

B. Digestion and Metabolism

1. Metabolism of fats. A study of the effect of a fat-free maternal diet on the growth rate and fatty acid composition of some tissues of the progeny showed that the depletion of the dams for 16 weeks did not affect the growth rate of the progeny. However, after the dams had been on the fat-free diet for 32 weeks the growth rate of the progeny was significantly depressed. As the depletion progressed, there was a reduction in the level of polyunsaturated fatty acids and an increase in monounsaturated fatty acids in the plasma and heart fat of day-old progeny. The level of linoleic acid decreased more rapidly than the arachidonic acid in these tissues. In the most severely depleted chicks, a rather high level of a C-20 triene was observed. The severity of depletion of the dams had no effect on the fatty acid composition of the tissues of the progeny after they had been fed a practical diet for 4 weeks.

A severe fatty acid deficiency was produced in the laying hen with recognizable symptoms, such as; extreme susceptibility to respiratory infection, and alteration in fat metabolism to produce in relatively large amounts an unidentified C-20 triene. Progressive severity of deficiency resulted in small egg size, prolongation of hatching time, together with a marked decrease in egg production, and eventually zero hatchability. When the depleted hens were fed purified linoleic acid, they recovered as completely and rapidly as those fed safflower oil which contains a number of unsaturated fatty acids. This is good evidence that linoleic is the only essential fatty acid. (AH e2-13).

2. Effect of additives on feed utilization. Studies were conducted at Glendale to determine the effect of furazolidone, oleandomycin, erthromycin thiocyanate, and the combination of procaine penicillin, and streptomycin on the performance of a high producing strain and a low producing strain of White Leghorn hens. All the data have not been summarized, but results to date indicate no effect on egg production or feed conversion with either strain (AH e2-13)

C. Nutritive Value of Feeds

1. Effect of feeding cottonseed meal or its constituents. In studies at Glendale in cooperation with the University of Arizona it was shown that feeding of cottonseed oil, together with crystalline gossypol, intensified the discoloration caused by gossypol in eggs cold stored for 1 or 3 months at 35°F. The cottonseed oil caused pink coloration in eggs.

Other tests indicated that oil dipping of eggs prevent yolk discoloration in stored eggs when the dietary level of free gossypol was less than 0.008 percent. Spraying with oil was effective at 0.001 and 0.002 percent levels of free gossypol when the storage temperature was 35°F., but not at 50-55°F.

Further studies showed that cottonseed oil at 0.1 percent level had no effect on yolk color of stored eggs, whereas 0.2 percent, or more, of cottonseed oil in the diet, and 3 mg/day, or more, of gossypol resulted in discoloration. Therefore, if the materials used in this study approximate the plant pigments and residual oil of cottonseed meal, it appears that laying diets containing less than 0.1 percent cottonseed oil and about 40 parts per million cottonseed pigments measured as free gossypol, would be satisfactory.

In tests to determine the carryover from feeding cottonseed meal to furnish 0.008 percent gossypol for the first 16 or 18 weeks of life, it was found that only slight discoloration appeared in relatively few eggs after 6 months storage. (AH e2-17)

2. Effect of calcium sources on shell quality. Tests conducted at Glendale showed that calcium gluconate in the diet did not improve whole egg weight, ratio of dried shell weight to whole egg weight, shell thickness,

or egg production over that obtained when ground limestone was the sole calcium supplement.

3. Fish solubles as a growth promoter. The results of an 8-year study showed that the addition of fish solubles to a practical diet adequate in all known nutrients, gave 6 percent increase in growth rate. When the data were summarized according to these periods (November through February), (March through June), and (July through October), analysis of variance indicated that year, period, dietary treatment, year x period and year x treatment effects were highly significant. The growth rate during the last three years of the study was significantly less than that of the preceding years. The response in November-February period was significantly higher than the other two periods. (AH e2-16)

4. Nutritive value of grains. Studies at Glendale, in cooperation with the University of Arizona, showed that when sorghum grains were compared with corn, the protein of three varieties was inferior and two varieites were equal to corn. However, when fed on an equal protein basis, one of these varieties was also inferior to corn. Supplementation with lysine did not improve the biological value of the sorghum grains.

Results obtained from a study of the effect of grains and corn oil on egg size, indicated that when chickens were maintained on diets containing corn, wheat plus corn oil or wheat plus lard from hatching through the first laying year, there was no consistent difference in egg size from the dietary treatments. These data are at variance with those published by other investigators. (AH e2-16)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Nutritive Requirements

Heywang, B. W., and Vavich, M. G. 1962. Energy level of a sixteen percent protein diet for layers in a semiarid, subtropical climate. Poultry Sci. 41: 1389-1393 (AH e2-15).

Heywang, B. W., Vavich, M. G., and Reid, B. L. 1963. Supplemental methionine in a sixteen percent protein diet for laying hens. Poultry Sci. 42:245-259 (AH e2-15).

Digestion and Metabolism

Miller, E. C., Menge, H., and Denton, C. A. 1963. A 40-week study with laying hens fed a low-fat diet. Fed. Proc. 22(2): 201 (Abstract) (AH e2-13).

Miller, E. C., Menge, H., and Denton, C. A., 1963. The effects of long-term feeding of a fat-free diet to laying hens. J. Nutrition 43(4): (AH e2-13).

Nutritive Value of Feeds

Kemmerer, A. R., Heywang, B. W., Nordby, H. E., and Phelps, R. A. 1962. Effect of cottonseed oil on discoloration of cold storage eggs. Poultry Sci. 41: 1101-1103 (AH e2-17).

Heywang, B. W., and Lowe, R. W. 1962. Egg shell quality during hot weather with calcium gluconate in the diet. Poultry Sci. 41: 1213-1215 (AH e2-15).

Heywang, B. W., Kemmerer, A. R., and Lowe, R. W. 1962. Yolk discolorations from cottonseed meal when eggs were oiled before storage. Poultry Sci. 41: 131-133 (AH e2-17).

Lillie, R. J., Menge, H., and Denton, C. A. 1962. Evaluation of condensed fish solubles as a chick growth stimulant in an 8-year study. Poultry Sci. 41: 1202-1206 (AH e2-16).

AREA NO. 11: POULTRY - IMPROVEMENT OF VIABILITY

Problem. Leukosis continues to cause a higher mortality among chickens than any other disease. The yearly financial losses from leukosis mortality in the poultry industry of the United States are estimated to be in excess of $65,000,000.00. At this time when the margin of profit is small, it is more urgent than heretofore that additional emphasis be placed upon research with the hope that control measures may be developed.

Leukosis is prevalent in both young and older stock, and on most, if not all farms, where chickens are raised. The incidence of leukosis among chickens is influenced by the genetic constitution of the stock and by environmental factors. There is great need for basic information on the natural history of neoplastic diseases of poultry including modes of transmission, and their relative importance, and environmental as well as other yet undetermined factors which influence the development of neoplasia among infected birds. Genetic testing of inbred lines of chickens for the different disease entities involved in the avian leukosis complex will assist in clarifying the total problem. Furthermore, it is apparent that the disciplines of biochemistry and biophysics must now be emphasized and integrated into the research program in order to hasten the development of control measures.

USDA PROGRAM

The basic and applied research is conducted by pathologists, bacteriologists, geneticists, and virologists at the Regional Poultry Research Laboratory, East Lansing, Michigan. Some of the studies have as their objective the biological and physical characterization of the agent or agents causing visceral lymphomatosis and related neoplasms of the leukosis complex. Research is also underway on the pathogenesis of the three primary types of avian leukosis and other related neoplasms for the purpose of determining and evaluating their etiological, pathological, and immunological relationships. Efforts are being made to develop more rapid and more precise methods of virus and antibody detection and assay; to determine and evaluate the importance of serum antibodies in the spread of infection; and the development of neoplasms. Such information is required for the development and effective use of a vaccine. Work is in progress on the development of a killed as well as an attenuated vaccine.

There are three phases of genetics work related to avian lymphomatosis. One involves the development and maintenance of inbred lines characteristically different in their resistance to lymphomatosis and related neoplastic diseases. One susceptible line is maintained in isolation to minimize infection with the disease. These lines provide relatively uniform experimental material for the study of nongenetic factors controlling disease expression and incidence. The second phase involves studies of the modes

of inheritance of genetic differences in resistance to lymphomatosis and related neoplastic diseases. An objective of the second phase is to find efficient ways of identifying chickens genetically resistant to lymphomatosis as expressed by low mortality under field conditions. The third basic phase of genetics research has as its objective the study of the mechanisms of genetic resistance to viral neoplasms. Research in the area of epizootiology has been greatly expanded. Much of this will be done with commercial flocks and with hatchery operators. Financial support for these studies is provided by both the National Cancer Institute, NIH, and the American Cancer Society.

A cooperative project entitled "Studies on the epizootiology of avian lymphomatosis and related neoplasms" calls for the active cooperation of (1) the Epizootiology Section, Epidemiology Branch, National Cancer Institute; (2) the Animal Disease Eradication Division, and the Regional Poultry Research Laboratory, Animal Husbandry Research Division, ARS; and (3) the American Poultry and Hatchery Federation. Cooperative projects also include work located in New Jersey, Pennsylvania, and Virginia. A research contract is still underway at the Wisconsin Agricultural Experiment Station.

The Federal scientific effort devoted to the research in this area totaled 9.4 professional man-years. Of this number, 3.0 are devoted to studies of the causative agent of avian lymphomatosis; 1.3 to improvement through genetic methods; 2.7 to improvement through vaccination, feeding and management practices; 1.0 to epidemiology of leukosis, and 1.4 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Studies of the Causative Agent of Avian Lymphomatosis

1. Characterization of field isolates of leukosis virus. The oncogenic spectra of five of the newly isolated strains of avian leukosis virus were investigated in the inbred line 15I chickens. Dosage level of the virus, age at the time of inoculation, and route of inoculation were all shown to influence, to a marked degree, the neoplastic response. There were differences in the spectra of the strains but the general response was similar to that induced by virus of strain RPL 12. Among the neoplasms induced were erythroblastosis, endotheliomas, fibrosarcomas, nephroblastomas, osteopetrosis and visceral lymphomatosis. In addition, hemorrhages were a common cause of death in chickens inoculated intravenously as embryos with large doses of viruses. Neural and ocular lymphomatosis were conspicuous by their absence. In further attempts to induce the neural disease these strains will be inoculated into chickens of line 7 which is known to be highly susceptible to neural lymphomatosis.

The JM strain of lymphomatosis has been reported to induce the neural and ocular as well as the visceral forms of lymphomatosis. This strain was made available to us by the Massachusetts Experiment Station. It was found that line 7 chickens are much more susceptible than line 15I chickens to the JM strain. This is the reverse of what has been consistently obtained for many years with all other chicken tumor viruses heretofore studied. The JM strain caused primarily neural and gonadal tumors in line 7, whereas in line 15I the tumors were similar to those obtained with strain RPL 12. Successful transmission was obtained with 7 of 8 cellular suspensions, 2 of 4 filtered extracts, 1 of 2 centrifuged extracts, and 1 serum sample gave a negative result.

It is apparent that the virus of the JM strain is quite different in several aspects than that of strain RPL 12 or of 10 other, but similar strains, isolated from field "outbreaks" of lymphomatosis. (AH e6-10 Rev.)

2. Virus propagation and tissue culture. The transformation of normal chicken embryo fibroblast to neoplastic cells by the Rous sarcoma virus (RSV) is the important part of the RIF test. It has been found that different strains of the RSV vary widely in the morphology of the transformed foci and in the type of cells comprising the foci. These characters largely determine the ease of recognition of transformed foci, hence certain strains of RSV are preferred in all tests requiring assay of RSV.

Studies on the validity of the RIF (resistant inducing factor) test, an indirect tissue culture method of detecting and assaying the lymphomatosis and other leukosis viruses, have continued. Selected tissues and extracts have been assayed for virus by the RIF and the chicken inoculation methods as well as by examination with the electron microscope. Good agreement by the three methods has been obtained for most samples. Discrepancies have been confined to the samples with a very low virus content.

The RIF method has been used to survey the laboratory flock of inbred, susceptible line 15I White Leghorns. A total of 450 embryos of 50 hens have been tested by the RIF method. A moderate percentage gave a positive result despite the fact that all of the hens were negative for antibody. Further studies indicate that most, if not all, of the "positive results" were actually falsely positive for RIF. They seemed due to genetic or innate resistance of the embryo cells to transformation by the Rous sarcoma virus rather than to the presence of lymphomatosis virus.

The demonstration of genetic resistance has far-reaching implication since many investigators have recently started to use the RIF test and the possibility of genetic resistance of the embryo cells has not heretofore been recognized. (AH e6-24)

B. Improvement Through Genetic Methods

The studies of genetic resistance to Rous sarcoma virus have been extended to investigate the effects of the single dominant gene for susceptibility on the response of embryos and cultures of embryonic cells exposed to this virus. The results suggest that this single gene affects *in vitro* as well as *in vivo* resistance to Rous sarcoma virus. A backcrossing program to the resistant line has been initiated to investigate the effects of this single gene on the ability to produce Rous sarcoma virus antibody susceptibility to lymphomatosis and related characteristics. (AH e6-2)

The genetic testing, and testing for the presence of virus and antibody in the isolated susceptible line of chickens has been increased largely due to the availability of new methods of virus and antibody detection. (AH e6-3)

Cooperative studies with the Alabama Experiment Station have shown that donor-host differences at the B blood group locus contribute to skin graft rejection and splenomegaly when adult cells are injected into embryos. It was also found that the A and C blood group loci play a relatively small role in skin graft rejection. Some skin grafts are accepted permanently when exchanged between members of the same inbred line, suggesting that progress has been made toward producing histocompatible lines. (AH e6-28)

C. Improvement Through Vaccination, Feeding and Management Practices

Studies on the measurement, interpretation, and function of circulating antibodies have continued. Extensive data have shown that serums which do or do not neutralize the induction of erythroblastosis also have the same effect on the induction of visceral lymphomatosis. These data provide convincing evidence that these two different neoplasms are caused by the same virus. Thus, the *in vivo* neutralization tests based on the more rapidly developing neoplasms, erythroblastosis, can be used with confidence in any immunological studies of visceral lymphomatosis. Tests with the induction of erythroblastosis can be completed in 45 days when 11-day embryos are inoculated; whereas, a test based on visceral lymphomatosis requires at least 245 days for completion.

Further work with the *in vitro* RIF test has provided additional data that shows excellent agreement between this tissue culture method and the *in vivo* chicken inoculation method. This is true not only for the detection and measurement of virus but also of antibody.

Additional data provide confidence in the use of the Rous sarcoma virus for the detection and assay of leukosis-lymphomatosis antibodies. In only a small percentage of the serums tested have there been disagreements between the Rous sarcoma virus and leukosis strain RPL 12 virus neutralization. Such low percentages of discrepancies are of no significance in field studies of the occurrence of leukosis antibodies. However, they are

important in studies of the antigenic relationship between the various chicken tumor viruses. It would appear that the Rous sarcoma virus is antigenically quite similar but has important differences from all of the leukosis viruses that have thus far been isolated and studied.

Research on the improvement of the complement fixation test for the detection of leukosis and other tumor antibodies has continued. Variations in antigen preparation, incubation periods and concentration of the several complement components have been tested. No material increase in sensitivity has thus far been obtained.

The genetic constitution of the host and the amount or exposure dose of virus have been found to largely determine the immunological response. The route of infection, the age at the time of exposure, the immune status at the time of exposure, and the type of virus strain are additional factors which will be studied to assess the interrelationships and their influence on the immune response. Data thus far obtained with viruses of strains RPL 12 and RPL 29 have revealed that the induction of the immune response is closely correlated with respect to amount of virus to the induction of neoplasia. Untreated virus at high doses caused erythroblastosis and antibodies in almost all birds at about the same time. Moderated doses that cause visceral lymphomatosis after about 5 months have resulted in a high percentage with antibodies within 2 months.

Studies of virus preparations treated with various concentration of formalin or Beta-propiolactone have shown that relatively large amounts of these inactivating agents are required to eliminate the oncogenic potency of the RPL viruses. With a decrease in oncognic effect there was also a decrease in the immunity (antibody) response, thus indicating that inactivated virus had by itself little antigenic activity.

Other virus strains, routes of infection and the use of adjuvants will be tested in attempts to obtain a good immune response. (AH e6-17 Rev.)

D. Epidemiology of Leukosis

Four field studies are now in progress. None has been completed though the following observations have been made: (1) maternal Rous sarcoma virus antibodies have no major influence on occurrence of leukosis later in life; (2) the incidence of leukosis and occurrence of RSV antibody in adults is positively correlated; and (3) line 15I chickens under natural conditions of exposure have developed as high an incidence but require a longer time to death than chickens of some commercial sources. (AH e6-27)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Studies of the Causative Agent of Avian Lymphomatosis

Burmester, B. R. 1962. The vertical and horizontal transmission of avian visceral lymphomatosis. Cold Spring Harbor Symposia on Quantitative Biology 27: 471-477 (AH e6-10).

Gross, M. A., Burmester, B. R., and Mantel, N. 1962. Pathogenicity of a viral strain (RPL 12) causing avian visceral lymphomatosis and related neoplasms. IV. Virus bioassay based on a log-exponential distribution of host mortality times. J. Nat. Cancer Inst. 28: 1111-1124 (AH e6-10).

Okazaki, W., Purchase, H. G., Frederickson, T. N., and Burmester, B. R. 1962. Modification of complement fixation test for estimation of Rous sarcoma virus antibodies in turkey and chicken serums. Soc. Exp. Bio. & Med. 3: 377-380 (AH e6-17).

Walter, W. B., Burmester, B. R., and Cunningham, C. H. 1962. Studies on the transmission and pathology of a viral-induced avian nephroblastoma (embryonal nephroma). Avian Diseases 6: 455-477 (AH e6-10).

Walter, W. G., Burmester, B. R., and Fontes, A. K. 1963. Variation in the occurrence of erythroblastosis and osteopetrosis induced by virus from individual chickens infected with avian leukosis strain RPL 12. Avian Diseases, 7: 79-89 (AH e6-10).

Winton, B. 1963. The avian leukosis complex. McGraw-Hill Annual Yearbook of Science and Technology (AH e6).

Improvement Through Genetic Methods

Waters, N. F., and Burmester, B. R. 1963. Mode of inheritance of resistance to induced erythroblastosis in chickens. Poultry Sci. 42: 95-102 (AH e6-2).

AREA NO. 12: POULTRY - ENVIRONMENT AS RELATED TO BROILER LOSSES

Problem. Effective control of Air Sac Disease to reduce the continuing losses from condemnations is a major problem of the broiler industry. Since the presence or absence of pathogenic strains of the pleuropneumonia-like organism, Mycoplasma gallisepticum, largely determines whether chickens will develop Air Sac Disease in the presence of secondary invaders, such as E. coli, Newcastle disease or infectious bronchitis, the value of effective methods for control is evident. Addition basic information is needed concerning the behavior of the organisms associated with this disease complex and the host response to them. The great range in host response indicates that genetic variation, nutrition, environment, and management play a part in the severity of the response in individual flocks of chickens.

USDA PROGRAM

A basic and applied program of research directed toward the reduction of losses from broiler condemnations is to be conducted jointly by specialists in agricultural engineering, poultry management, disease, genetics, nutrition, and physiology. Two locations are involved in this work, the Southeast Poultry Research Laboratory, Athens, Goergia, and the South Central Poultry Research Laboratory, State College, Mississippi.

The Animal Husbandry Research Division's work at Athens emphasizes genetics and physiology in relation to the Air Sac Disease complex and the work at State College will emphasize environment and management in relation to condemnation losses.

This research program is cooperative with the Animal Disease and Parasite and Agricultural Engineering Research Divisions, ARS. Local cooperation of State experiment stations and the broiler industry in the southeast and south central regions is an important part of the program, particularly with respect to field trials.

The Federal effort devoted to research in the poultry management area totals 2.2 professional man-years. Of this number 1.0 is devoted to genetics in relation to airsacculitis, 1.0 to management in relation to condemnations, and 0.2 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Genetics in Relation to Airsacculitis

The Southeast Poultry Research Laboratory was dedicated on June 1, 1963, and is not yet fully operational. The program is just getting underway.

B. Management in Relation to Condemnations

No method of egg dipping offered sufficient promise of being of practical value to broiler raisers to justify further field trials.

Although management factors appear to be important in the development of airsacculitis, successful investigation of these factors requires almost constant observation on individual farms, because of the close supervision of unskilled operators required.

The use of a dried culture of Bacillus megatherium was tried on six farms with over 21,000 broilers and an equal number of untreated controls. No favorable value was observed. None of the various treatments to control avian nephrosis have been effective. Treatments have included antibiotics, vitamins, sulfamethazine, molasses, and disinfectants.

Installation of partitions in order to reduce drafts have been effective in raising broiler house temperatures in cold weather. (AH e7-1)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

None

AREA NO. 13: SHEEP AND GOATS--BREEDING

Problem. The existence of the sheep industry in this country will depend upon sheep producers being able to effectively and efficiently meet competition from other sources of meat and fiber. To meet this competition the farm sheep producer will need more efficient sheep, sheep which are capable of year-round production of more lambs and wool per ewe, often under adverse environmental conditions and with more resistance to disease and parasites. Range sheepmen need information on genetic methods of improving lamb and wool production. More effective systems of mating, breeding and selection need to be tested. Breeding studies on reproductive efficiency, as well as on the inheritance of feed efficiency, rate of gain and carcass quality deserve emphasis. Basic research on the inheritance of blood antigens is needed to implement other sheep genetic studies.

USDA PROGRAM

This is a continuing program by geneticists on basic and applied studies of breeding to increase efficiency of production of high quality lamb and wool. Work in progress at Beltsville, Maryland, involves breed comparisons and studies of gains resulting from crossing of breeds. At Dubois, Idaho, systems of mating are compared including development and crossing of inbred lines and selected strains. Also studies on heritability and other genetic parameters of economic traits, as well as studies on improved methods of selection are conducted. At Fort Wingate, New Mexico, and on a private ranch in Utah, selection studies are emphasized. Inheritance of blood antigens is being investigated in cooperation with the California Experiment Station. Cooperation is maintained with 15 other State experiment stations. Several of the studies contribute to the western, southern and north central regional sheep breeding projects.

The Federal scientific effort devoted to research in this area totals 6.3 professional man-years. Of this number 1.5 are devoted to genetics and interrelation of performance traits, 3.1 to selection and systems of breeding, and 1.7 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits

1. Environmental interactions. Because proper interpretation of important environmental effects on various performance traits is dependent on knowledge concerning the presence or absence of interactions among the different categories of effects, the importance of two-way environmental interactions was examined on 39 weanling and yearling traits of 4452 Rambouillet, Targhee and Columbia ewes at Dubois, Idaho. The most important interaction discovered was that between year of record and band in which

the lamb was reared. This interaction was significant for approximately 50% of the 14 weanling traits examined and 10% of the 25 yearling traits examined. The next most important interaction was that between year of record and type of birth and rearing, which affected about 8% of the weanling traits and 12% of the yearling traits. The two least important were those between age of dam and band and those between age of dam and years; the former affecting only 2% of the weanling traits and 5% of the yearling traits involved. Other interactions examined were between type of birth and rearing and age of dam and between type of birth and rearing and band. In general, interactions involving years were most important and those involving age of dam were least important. It appears that the magnitudes of many environmental effects are conditioned by the year in which the effects occur. This emphasizes the importance of making breeding tests and comparisons over a period of years. Also, where important interactions occur, adjustment factors must be determined each year. (AH b1-6)

2. Heritabilities and phenotypic, genetic, and environmental correlations. Heritabilities and correlations among eight weanling traits of Rambouillet, Targhee, and Columbia topcross lambs were examined at Dubois, Idaho, in cooperation with Montana State College, Bozeman, Montana. Estimates of heritabilities in the three breeds ranged from 17 to 25% for weaning weight, 53 to 100% for face cover, 0 to 50% for neck folds, 1 to 55% for body type, 16 to 40% for condition (fatness), 10 to 72% for staple length, 19 to 62% for wool grade, and 0 to 31% for crimps per inch. Phenotypic, environmental, and genetic correlations among weaning weight, type, and condition were all moderately large, generally above 0.5, the heavier animals having better type and condition both phenotypically and genetically. However, because of the generally low heritabilities for all three traits, mass selection for any one is unlikely to importantly influence either of the others genetically in all three breeds. Genetic improvement in weanling staple length is likely to be accompanied by a genetically coarser wool grade at weaning (genetic correlations being 0.6 or higher whereas phenotypic correlations are all less than 0.6). Because heritability for staple length in Rambouillets is appreciably higher than for side grade, mass selection on staple length in this breed would be slightly more effective in changing side grade than selection on side grade itself. Most other genetic correlations among the eight traits are unimportant or the sampling errors are obviously so large as to render the interpretation questionable. Important environmental correlations between body type and staple length, and between crimp and staple length cause phenotypic correlations to be higher than comparable genetic correlations would indicate. (AH b1-6, AH b1-14)

At Fort Wingate, New Mexico, data on 1075 yearling ewes were analyzed to obtain heritability estimates, genetic and phenotypic correlations among seven traits: body weight, body type, body condition, staple length, fiber diameter, grease fleece weight, and clean fleece weight. The ewes were from three separate breeding groups of improved Navajo and Navajo crossbred types and were born over the 14-year period 1947-1960.

The three body traits (body weight, body type, body condition) were found to have moderate to high genetic and phenotypic relationship. Highly significant positive phenotypic correlations were obtained among the fleece traits (staple length, fiber diameter, grease fleece weight, clean fleece weight). The most important genetic correlations among the fleece traits were 0.93 between grease fleece weight and clean fleece weight and 0.44 between staple length and clean fleece weight. The genetic correlation of -.24 between staple length and body weight appeared to be the only one which would handicap selection. The genetic relationship between clean fleece weight and fiber diameter was found to be negligible. Heritability estimates fell in the moderate range (0.20 to 0.40) for all but two traits: body type (0.17) and clean fleece weight (0.19). (AH b1-10, AH b1-11, AH b1-12, AH b5-6)

3. Correlation among traits. Analyses at Dubois, Idaho, of 5 year's data obtained on the efficiency of gain of 226 individually fed Rambouillet ram and ewe lambs (39 traits) and a comparable lot of 218 group fed lambs (23 traits) have provided additional estimates of the effects of age of dam, type of birth and rearing, sex, band and age of lambs, on efficiency of feed conversion and rate of gain on feed test. Phenotypic correlations, independent of measurable environmental effects, were calculated among all traits studied. Feed lot performance traits significantly correlated with efficiency of gain included rate of gain (-.62), initial body weight (.40), initial type (-.22) and initial condition (-.16). No significant correlations were found between feed efficiency and the remaining feedlot performance traits (daily feed consumption, final type, final condition, and increase in wool staple length during the test period). Correlations between efficiency of gain and birth, weaning and yearling traits were low and most lacked statistical significance. Rate of gain during the test was significantly correlated with daily feed consumption (.78), final body weight (.55), grease fleece weight (.35), yearling body weight (.33), gain from birth to weaning (.24) and variability of fiber diameter (.21). Rate of gain was not significantly correlated with any of the other traits studied. Estimated heritability of feed efficiency for the first 42 days, second 42 days and 84 days on the feed test was .65, .35, and .26, respectively. (AH b1-13)

4. Factors affecting rate of gain in lambs. A study was conducted at Fort Reno, Oklahoma, Livestock Research Station, to determine the consistency of differences in gain in weight from about 50 to 90 pounds between classifications of birth weight, breed of dam, birth and rearing type and sex for lambs from the same group of ewes in different years. Seven separate analyses were made for each of the four years involved with different combinations of the above classifications. The constants obtained for birth weight changed very little from year to year regardless of the other variables included in the analyses. The magnitude of the differences of the estimates of daily gain due to birth weight increased each year as the ewes became older. Estimates of the difference in daily gain due to type of birth and rearing changed rather drastically from year to year.

The constants obtained when birth weight was omitted from the model were also different than when it was included as a variable. Constants obtained for sex differences also increased as the ewes became older or with time. These constants changed with the inclusion of birth weight in the analysis which indicated a correlation between the two variables. This study indicates that the accuracy of adjustment factors may be improved if obtained from a least squares analyses and containing only the sources of variation for which adjustments are to be made. (AH b3-7)

5. Investigation of blood group relationships in sheep. Cooperative work with the University of California at Davis, concerned with blood groups in sheep, has been continued. California workers first diagnosed the occurrence of a freemartin ewe in 1953 on the basis of having red cells of two distinct types which she shared with her co-twin, a ram. Three such cases of freemartin ewes have now been diagnosed and confirmed in the University of California sheep flock. It appears that either freemartin occurs in sheep much more frequently than is generally supposed or that the University flock is somehow predisposed to producing freemartins.

A total of 21 additional isoimmune antisera was produced and collected during the year to replenish the stock supply of certain reagents. A new reagent prepared from an isoimmune antiserum coded S106 was found to be reactive in the M system of ovine blood groups. Its reactions permit definition of a new phenogroup designated M^1 corresponding to the name given the reagent.

Some 5,185 statistical tests involving four years of data from sheep at Davis and Hopland, California, and Dubois, Idaho, on relationships of blood types with production traits have been made. The analyses have as yet shown no consistent trends in all years within a breed or in all years between breeds for any of the various combinations of blood types and production traits under comparison. On the other hand, genotypes of three blood group loci, namely, A, D and R-O, appear to be clearly associated with certain components of fitness, namely, ovulation rates, conception rates, and both prenatal and postnatal lamb mortalities. (AH b1-15)

B. Selection and Systems of Breeding

1. Breed comparisons and crossbreeding. This work was undertaken at Beltsville, Maryland, to compare breeds with respect to their ability to produce wool and lamb, and their relative merit in a crossbreeding program. Specifically this report covers that portion of the study dealing with the effect of crossbreeding on weaning weight, birth weight and gain from birth to weaning. This work includes a total of 4331 lambs born and 3423 lambs weaned during the years 1952-1961, inclusive. It involves data from four purebred groups of sheep including Hampshire, Shropshire, Southdown, and Merino and one strain evolved from a Columbia-Southdale cross. The work also includes seven groups of first or 2-breed cross lambs from Hampshire, Shropshire, and Southdown rams and from Hampshire, Shropshire, and Merino

ewes; 15 groups of 3-breed cross lambs from 2-breed cross ewes and purebred sires of Hampshire, Shropshire, Southdown, and Merino breeding, plus two groups of lambs sired by crossbred rams and from Merino ewes. Six groups of 4-breed cross lambs were from 3-breed cross ewes and from Southdown and Merino sires.

From a detailed analysis of factors affecting birth weight, weaning weight and daily gain, it was found that years, sex, type of birth, age of dam, and breeds and crosses all had significant effects on birth weight. The interactions involving sex X years, sex X type of birth, sex X age of dam, and sex X purebred or crossbred were all non-significant. For weaning weight it was found that years, sex, type of birth and rearing, age of dam, the regression of weight on age, and breeds and crosses all had significant effects. It was also found that the interactions of years X sex, sex X type of birth and rearing, sex X age of dam, sex X purebred or crossbred, sex X high or low year, age of dam X high or low year and the regression due to date of birth were all found to be significant except years X sex and sex X age of dam.

The purebreds ranked in the same order for both birth weight and weaning weight, with the Hampshires highest, followed by the Columbia-Southdale, Shropshire, Merino, and Southdown. The pure breeds also ranked the same for gain from birth to weaning except that the gain for the Southdowns was slightly greater than for the Merino, but their difference was not significant. The two-breed cross offspring tended to rank in the same order for all three traits as the purebred lambs from the dams breeds. The offspring also tended to rank in the order of the sire breed within a dam breed, although there were some exceptions. Differences between crosses were not so readily apparent within 3-breed and 4-breed crosses. Offspring from crossbred rams mated to purebred ewes excelled over the purebreds, but not over offspring from purebred sires mated to crossbred ewes. Advantages of all crossbred lambs over purebred lambs involving the same breeds were 7 pounds for weaning weight, 0.63 pounds for birth weight, and 6.5 pounds gain from birth to weaning. Crossbreds always excelled over the comparable averages of the purebreds making up the cross for each trait. The average gain in weaning weight over the purebreds was 5.2 pounds for the 2-breed cross, 9.5 pounds for the 3-breed cross, and 10.4 pounds for the 4-breed cross. (AH bl-1, AH bl-2, AH bl-3, AH bl-4)

2. <u>New strains of sheep for lamb and wool production.</u> In many areas of the United States it would be advantageous if lambs could be produced at any time of the year. However, this is not feasible now as our present domestic breeds do not reproduce in abundance except during the winter and spring. More intensive and more efficient lamb production, especially in farm flocks, would be greatly facilitated by strains of sheep which would efficiently reproduce every 6 to 8 months and do this without seasonal restrictions. Thus, work has been started at Beltsville, Maryland, on the development of a strain of sheep capable of reproducing more than once per year. The development of such a strain of sheep will demonstrate the

effectiveness of selection in changing reproductive frequency and in removing seasonal restrictions on reproduction. The present plans envisage the development of a complete reproductive cycle each 8 months resulting in three lamb crops in two years. Matings are made in April, December and August and the lambs are weaned at about 60 days of age in December, August and April.

To date 168 ewes have lambed and 156 lambs have been weaned. There is considerable annual variability in fertility and lamb mortality particularly for September lambing. A total of 15 ewes each lambed three times in the first two years weaning 53 lambs. Present sires were born in the first fall lambing from mothers which each have since lambed three times in two years. (AH b1-17)

3. Comparisons of breeding systems. Preliminary results at Dubois, Idaho, based on weanling progeny from 46 Targhee and 26 Columbia sires randomly selected from the upper and lower halves of each breeding group and tested on an unrelated tester stock (eight test ewes per sire) show inbred Columbia sires to be only slightly better than purchased, stabilized control, and selected control sires for both weaning weight and overall merit (index). The superiority in overall merit was due principally to differences in weaning weight. The range from poorest to best system was 6 pounds in weight and 2.5 points in index. In the Targhee, selected control sires were superior in both weaning weight and overall merit, the superiority in weight being negligible. The range from poorest to best system was only 4 pounds in weight, but 12.8 points in merit. The superiority in merit was due principally to more open faces, less wrinkled necks, and slightly longer staple lengths. Recurrently selected inbred sires were second in overall merit, chiefly due to longer staple lengths. Stabilized control and purchased sires were poorest and about equal in overall merit, although weaning weights from purchased sires were equal to those of selected control sires.

When the evaluations of the systems were based upon offspring produced entirely within the system, i.e., produced by both sires and dams from within the system, the earlier pattern of selected control superiority and inbred line inferiority was clearly repeated in all three breeds (including Rambouillets) with the stabilized controls ranking near or slightly above the inbred lines in weaning weight and overall merit. However, the stabilized controls distinctly surpassed the inbred lines in pounds of lamb weaned per ewe bred by from 6 to 16 pounds. Comprehensive line cross information from nearly every Targhee and Columbia line placed the line cross offspring on a par with the selected control in both average weaning weight and overall merit. The pounds of lamb weaned per ewe were about 16 pounds less in the Targhee line crosses than in the selected control although unimportantly superior to the selected control in the Columbia line crosses. Line cross and inbred line production each were adjusted for the effects of inbreeding of the dams. These results tend to contradict earlier line cross results

based on crosses from only 1/3 to 1/2 of the lines in each breed which generally placed the line crosses in an intermediate position.

Production indexes for mature ewes based on lifetime average annual pounds of lamb weaned per ewe bred plus three times the average grease fleece weight give control ewes (including both selected and stabilized control) a 22 point advantage in Rambouillets, a 9 point advantage in Targhees, and a 9 point advantage in Columbias over the inbred line average. (AH b1-5)

4. Testing of inbred lines. The first year's data have been obtained on a comprehensive line testing program at Dubois, Idaho. The data include results on topcross and linecross weanling progeny from 40 Targhee and 20 Columbia sires (randomly selected) representing 20 Targhee and 10 Columbia inbred lines at Dubois.

Results from Targhee topcrosses on an unrelated tester stock ranked lines 8T, 15T, 14T, 5T, 20T, 1T, and 17T in the order given as being the top third for overall merit (index). These lines ranged from 155.71 to 151.42 in average index, with the average for all Targhee topcrosses being 148.45. The linecross results ranked lines 17T, 14T, 7T, 1T, 12T, 15T, and 3T as the top third; with indexes ranging from 168.03 to 161.76. The average index for all Targhee linecross progeny was 160.74. Indexes for all linecross progeny were adjusted for the inbreeding of the dams. Lines 17T, 14T, 15T and 1T were among the top third in both tests.

The top third of the Columbia topcross results include lines 9, 7, 8, and 5, with indexes ranging from 148.12 to 144.50; 143.47, being the mean of all Columbia topcross progeny. The Columbia linecross progeny ranked lines 5, 6, 2, and 7 in order as the top third with indexes ranging from 148.80 to 147.69; the overall mean for Columbia linecrosses being 146.72. Note that lines 5 and 7 were common to both groups in these independent tests for general combining ability.

It was noted that the correlation between each line's own merit as an inbred line and its response in top and linecross tests was only moderate to low. (AH b1-5, AH b1-14)

5. Selection for range sheep improvement. Research on the rate of improvement in wool and lamb production resulting from a practical breeding and selection program under range conditions is being investigated at the Redd Ranches, La Sal, Utah, in cooperation with the Utah and Colorado State Experiment Stations.

A super flock initiated with approximately 1000 ewes selected from the entire flock of over 15,000 ewes, was set up in 1957. Selected rams were originally mated to this group and the top rams and ewes produced from the super flock have been used for its replacements since. Rams produced from the super flock are mated to selected bands of ewes from the main flock to produce replacement ewes for the main flock. The remainder of ewes from the main

flock are mated to meat breed sires to produce market offspring.

In the first 3 years from 40 to 49 percent of the ram lambs weaned have been saved for possible use in breeding. Selection differentials in these have ranged from 10 to 11 pounds for weaning weight, 0.09 to 0.14 inches for staple length, and 0.12 to 0.24 score for face covering. Indications of improvement based on yearly trends are evident for weaning weight, staple length, face covering, and polledness. (AH b1-16)

6. Selection of ewes on early production records. Seven years of production records for 167 ewes in the Fort Reno, Oklahoma, experimental flock were studied to determine how the ewes might have been culled during the first year or two of production to create more efficient flock productivity. The production traits studied were whether or not the ewes lambed during the fall of their first, second or both years; their level of lamb production during their first two years; their frequency of raising the lambs produced; the birth weight, 70 day weight and post 70 day rate of gain of their lambs; and the weight of wool produced yearly.

Culling the ewes that failed to lamb during the fall of their first year would not have resulted in appreciable improvement. Culling the ewes that failed during their second year would not have required such heavy culling as culling on first year's performance and would have resulted in more improvement. The data suggested that ewes that failed to lamb during the fall in both of the first two years could be culled with considerable assurance of removing ewes that would be lower-than-average producers for the rest of their lives. Ewes that had twins during either or both of their first two years raised 19 and 33 percent larger lamb crops for the next five years than ewes that did not.

Culling ewes that lambed but failed to raise one or more lambs during their first two years would not have changed the flock productivity appreciably.

The repeatability of birth weight on unadjusted data was low but was moderate when the data were adjusted for the sex, type of birth and age of dam of the lamb and the year in which he was born. The weight of the lamb(s) at 70 days of age and rate of gain from 70 days to market weight (about 90 pounds) were traits of low repeatability in these data and consequently one evaluation of a ewe for these traits would not give one a sound basis for culling.

The repeatability of fleece weight was high when calculated for these ewes plus two groups of Dorset X Rambouillet crossbred ewes that were raised. Thus the culling of ewes that sheared the lightest fleeces would be efficient from the point of view of increasing the weight of wool sheared by the flock but unless light shearing ewes were also poorer than average performers for lamb production, they probably should not be culled. (AH b3-7)

7. Effect of pregnancy and lactation on wool production. A study was completed from Fort Wingate, New Mexico, involving the effects of type of parturition, lactation and subsequent pregnancy on grease and clean wool production. Included were 2424 records of grease fleece weights taken during the years 1955-59 and 1451 clean fleece weights taken from 1957-59. The ewes were sheared just before lambing.

The effects of parturition and lactation upon wool production were very pronounced with ewes giving birth and nursing twin or single lambs producing significantly less grease and clean wool than ewes producing no lambs. The effects of pregnancy were not as pronounced as were those for parturition and lactation. Ewes pregnant with a single lamb did not produce significantly less grease wool than ewes which failed to lamb; however, the difference in clean wool yield was significant.

These results indicate that selection in mature ewes for increased wool production should be made only after adequately accounting for the effects of lactation and pregnancy. (AH b5-6)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Genetics and Interrelations of Performance Traits

Brothers, D. G., Whiteman, J. V. 1962. Inconsistency of partial regression coefficients for variables affecting lamb rate of gain. J. Anim. Sci. 21(4), pp. 824-828 (AH b3-7).

Selection and Systems of Breeding

Ercanbrack, S. K., Blackmore, D. W., Van Horn, J. L., Blackwell, R. L., Hoversland, A. S., Kyle, W. H., Drummond, J., Terrill, C. E., and Willson, F. S. 1962. Weanling performance of top cross progeny from inbred and noninbred rams. J. Anim. Sci. 21(4), p. 972 (Abstract) (AH b1-6).

Sidwell, G. M., Everson, D. O., and Terrill, C. E. 1962. Fertility, prolificacy and lamb livability of some pure breeds and their crosses. J. Anim. Sci. 21(4), pp. 875-879 (AH b1-17).

Whiteman, J. V., Harrington, R. B., Nichols, C. W. and Bosler, W. L. Jr. 1963. Which ewes should we cull? Oklahoma M. P. 70, pp. 5-14 (AH b3-7).

AREA NO. 14: SHEEP AND GOATS--PHYSIOLOGY

Problem: Inefficient growth and reproductive failures are costly to sheep producers and cause large reductions in efficiency of production. Additional information is needed on the causes of reproductive failures in the female and low fertility or sterility in the male. Also, more information is needed regarding the basic physiological processes involved in growth and reproduction. The normal physiology of all phases of growth and reproduction must be more thoroughly defined along with the effects of important genetic and environmental factors such as breed, age, season and level of nutrition in order to develop more effective ways of increasing efficiency. Basic information is also needed concerning the development and growth of fiber follicles in order that further improved practices can be developed for wool and mohair production. This research requires studies on the nature and sequence of histological, cytological, and physiological processes involved in fiber follicle initiation and development.

USDA PROGRAM

This is a continuing program conducted by physiologists and histologists on basic and applied studies of the physiology of reproduction, growth, and development of sheep and goats, including processes involved in fiber follicle initiation and development. Factors influencing mating behavior, estrus, ovulation, and embryonic development in ewes and mating behavior and fertility of rams are directed toward a more complete understanding of the reproductive processes in sheep. The work is in progress at Beltsville, Maryland; Dubois, Idaho; and cooperatively with Idaho and Oklahoma State Agricultural Experiment Stations. Environmental factors affecting growth and development are being studied in cooperation with five State experiment stations. One study contributes to the Western regional project W-46 on the effects of environmental stresses on range cattle and sheep production. Studies on fiber and follicle development of sheep and goats are in progress at Beltsville, Maryland, in cooperation with the Texas Agricultural Experiment Station.

The Federal scientific effort devoted to research in this area totals 2.5 professional man-years. Of this number 0.7 are devoted to physiology of reproduction, 0.1 to environmental physiology, 1.3 to physiology of wool and fiber, and 0.4 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Flushing studies with range sheep. Columbia ewes at Dubois, Idaho, were supplemented with 0.5 or 1.0 pound of oats per head per day for 17 or 34 days prior to breeding. Oat straw was used to lower the condition of two of the treatment groups prior to administration of the oat supplement. Results indicate a year x treatment interaction on lamb production. None of the flushing treatment applied in the fall of 1960 resulted in a greater response than the unsupplemented control. In the fall of 1961, following fall rains which produced a good regrowth of grass prior to breeding time, the six flushing treatments increased lambing rates by an average of 6.5% more lambs born than the untreated control. The 1962 trial resulted in three of the flushing treatments exceeding the control and three resulting in fewer lambs born than the control. When the three years were averaged together there was little difference between the controls and treatment groups. One treatment which exceeded the controls (1 pound oats per ewe per day for 34 days) over the entire three year experiment produced only 5% more lambs than the controls. This benefit would not pay for the additional feed required. (AH b1-7)

2. Mating behavior.

a. Studies on behavior, semen production and fertility of sexually inhibited rams. Fifty-three purchased rams, 54 Sheep Station ram lambs and 2160 Sheep Station yearling and mature rams have been semen tested at the U. S. Sheep Experiment Station, Dubois, Idaho, during the past 8 years. Six percent of the purchased rams, and 13 percent of the Sheep Station ram lambs failed to copulate with nonestrual or estrual ewes under semen testing conditions compared with 32 percent of the Sheep Station yearling and mature rams. This indicates a problem exists in predicting probable fertility of a large number of rams due to inability to obtain naturally ejaculated semen samples for examination and to the poor predictive value of information obtained from electroejaculated samples. Such rams that fail to mate naturally have been referred to as "no work"rams.

One hundred and three "no work" rams were used in breeding from 1956 to 1960. The average lambing date of 1,378 ewes mated to 90 of the 103 "no work" rams was 1.4 days later than the average of an otherwise comparable group of 1,356 ewes mated to 90 normal rams. In addition, the remaining 13 of the 103 "no work" rams were either removed from breeding because of failure to breed (10) or had zero fertility (three).

The time required for "no work" rams to start working was studied in a group of 27 normal rams and 23 "no work" rams. All of the normal rams had copulated within 24 hours as compared to 35 percent of the "no work" rams. Seventy percent of the "no work" rams started mating activity within 48 hours, 79 percent within 72 hours, and 83 percent within 120 hours.

Another ram (four percent) worked after 14 days with the ewes. The remaining three rams (13 percent) were removed at eight or nine days for failure to breed.

The average fertility for the normal and "no work" rams was 93 and 76 percent, respectively. Selection of the normal rams on the basis of the naturally ejaculated semen sample accounts for a part of the difference in fertility between the two groups. Failure to breed or delay in breeding probably accounts for all or nearly all of the remaining difference.

There were no important differences in the quality of electroejaculated semen samples obtained from 97 normal and 43 "no work" rams. However, it was found that, though the above rams were used in breeding independent of semen quality evaluation, the semen quality traits of the normal rams were much more highly correlated with fertility than those of the "no work" rams (0.65 vs. 0.30, respectively).

The "no work" trait does not appear to be associated with inbreeding but does appear to be heritable. Once a "no work" ram begins working his libido appears to be entirely normal. (AH b1-7)

b. Breeding capacity of Targhee rams. Six pens of Targhee ewes (26 to 34 ewes per pen) at Dubois, Idaho, were synchronized for estrus with daily injections of 10 mg. of progesterone per day for 12 days. The ewes were put into breeding at the second post-treatment estrus and observed continuously for three days. One ram was used in each pen.

A large proportion of the ewes came into heat within the three-day period. In each pen the maximum number of matings occurred during the first 24 hours. The most active ram mated 48 times in the 24-hour period. The slowest ram mated 31 times. The average was 37 matings during the first 24 hours and 26 matings per 24 hours for the three days. The percent of ewes lambing to first service varied from 68 percent to 34 percent with an average of 48 percent. Eight percent to 38 percent of the ewes in the six pens were not observed in heat during the three-day observation period. The percent of ewes lambing to pen mating (35 days) ranged from 73 percent to 94 percent with an average of 87 percent. This percentage in the synchronized pens was slightly above the average (86%) for a comparable group of unsynchronized Targhee and Columbia ewes bred in pens of five ewes per ram. A higher proportion of the synchronized ewes lambed from the entire breeding season (which included range breeding after pen breeding for a total of 59 days) than of the unsynchronized ewes (93% vs. 87%). (AH b1-7)

3. Effects of the light environment on reproductive phenomena. Effects of variation in the light environment on ovulation rate, embryo survival and gonadotrophic content of the pituitaries of mature ewes during the breeding season are being studied at Dubois, Idaho, in cooperation with Utah State University. Except for hormone assay preliminary results from the first two years are now available.

The ewes were synchronized for estrus with intramuscular injections of progesterone in oil and subjected to continuous light, continuous dark or natural daylight (control) at about the time of the first estrus following synchronization. After 17 days half of the ewes in continuous dark were shifted to continuous light and half on continuous light were shifted to continuous dark. The ewes were slaughtered at approximately 3 and 25 days gestation in 1961 and 3 and 34 days gestation in 1962 to obtain ovulation and embryo survival rates. Continuous dark resulted in a consistently though not significantly higher ovulation rate (207%) than the control (197%). Light treatment had a marked effect on ova recovery rate. The recovery rate for the continuous dark group was consistently much poorer (ave. 65%) than the control (80%) or other treatments (82%). It is possible that ova degeneration accounts for this rather marked difference. Embryo survival rate was significantly affected by the light treatments. The continuous dark treatment had the lowest percent of normal embryo in relation to the number of copora lutea at 25 and 34 days of gestation in each of the two years (56%) as compared with 80% for the control, 71% for the continuous light and 84% for those groups switched from one light regime to another. No information is yet available on pituitary gonadotrophins. (AH b1-7)

4. Synchronization of estrus with orally active progestin. The effect of dosage (50 mg. vs. 60 mg.), length of treatment period (12 days vs. 14 days) and breeding at first or second post-treatment estrus on synchronization of estrus and lambing were compared at Dubois, Idaho. The hormone was incorporated into an all alfalfa pellet and fed to the ewes by groups.

The results indicate little difference in synchronization of estrus due to any of the treatments. Approximately 85% of all ewes came into heat within a four day period. However, 82 percent of the ewes mated for the first time at second post-treatment estrus lambed within a 12-day period compared to only 64 percent of those mated at the first post-treatment estrus. The latter percentage is very close to 61 percent fertility obtained a year ago under similar treatment conditions. It appears that synchronization is maintained very well until the second post-treatment estrus, and fertility is markedly improved by mating at this time compared to the first estrus following treatment. It is planned to repeat the experiment one more year. (AH b1-7)

5. Relationships of semen quality to fertility. Electroejaculation was compared with natural ejaculation for obtaining semen samples to predict ram fertility at Dubois, Idaho. The rams (140) were assigned independent of semen quality to breeding pens containing from 5 to 65 ewes. The data consisted of ram fertility as measured by percent ewes lambing of ewes present at lambing and semen traits (pH, volume, motility, concentration and morphology). When possible, two consecutive naturally ejaculated semen samples and two electrically ejaculated samples using two different ejaculators were obtained from each ram. Natural ejaculates were obtained from 94 rams and both natural and electroejaculates were obtained from 83 rams.

Electrically ejaculated samples were inferior in quality to naturally ejaculated samples. Correlations between semen quality traits and fertility were lower for all traits except pH and concentration when electroejaculated samples were compared with naturally ejaculated samples from the same rams. Correlations that were significantly different ($P>.05$) from each other involved morphological traits.

Information from the second of the two natural ejaculates was slightly more effective in predicting ram fertility than the same information from the first sample ($R = 0.74$ vs. $R = 0.69$). The predictive value of the second sample was also slightly superior to the mean of the first and second samples obtained naturally. Selecting the better of the two naturally ejaculated samples did not improve fertility prediction over routinely selecting second ejaculates. Retesting rams with initial low-quality samples did not improve fertility prediction.

It is concluded that natural ejaculates should be employed where possible or practical when attempting to predict fertility. Electroejaculation should be limited to use as a supplement or alternate to natural ejaculation when it is either impossible or impractical to obtain the natural ejaculate. The selection of the second natural ejaculate of each ram is the most efficient method of sampling a ram's semen for the purpose of predicting fertility of those studied.

Semen quality and ram fertility were studied in relation to the fecundity of ewes as measured by the percent of lambs born to ewes that lambed at Dubois, Idaho. The multiple correlation between six semen traits of the ram (motility score, percent motility, percent live normal cells, percent abnormal cells, percent abnormal necks and percent abnormal middlepieces) and fecundity of his mates was 0.49. The correlation between ram fertility (percent of ewes lambing of those present at lambing) and fecundity was 0.62.

Thus it appears that the fecundity of the ewe may be affected by the relative fertility of the ram in that the more highly fertile rams may fertilize a higher proportion of eggs ovulated by ewes than rams of lower fertility. (AH b1-7)

6. Fetal electrocardiography in the ewe. Preliminary studies were made at Beltsville, Maryland, of electrocardiography in the pregnant ewe to determine if pregnancy could be accurately diagnosed with this method. Such a method would not only indicate pregnancy but might also be used to detect number of offspring in multiple births. Practical methods of early pregnancy diagnosis in sheep are not available except by laparotomy. Such diagnosis would be of considerable advantage in management particularly under intensive production of more than one lamb crop per year. Preliminary results were inconclusive and indicated difficulties in making clearcut determinations. (AH b1-17)

B. Environmental Physiology

1. Effect of location on productivity of Targhee sheep. Production data on Targhee sheep are being collected in Hawaii; at Dubois and Moscow, Idaho; Fort Wingate, New Mexico; Spooner, Wisconsin; and Beltsville, Maryland.

Targhee rams were used in a topcrossing experiment to test their value for improving lamb production in Hawaii. In 1960 Targhee rams were mated to a sample of commercial ewes and the topcross offspring were compared with a control group of commercial lambs out of comparable ewes. Records at weaning (142 days) were available on 104 Targhee topcross lambs and 153 control lambs. All records were adjusted for the effects of sex and age of lamb and type of birth and rearing. The Targhee topcross lambs were 4.1 pounds heavier, had a slightly better score for mutton type, had a 9 mm. longer staple, and had a slightly coarser fleece than the control lambs. Only the difference in weaning weight was statistically significant ($P<.05$). These results indicate that Targhee rams could be used to improve weaning weights of lambs in Hawaii with little or no change expected in type score, staple length, and wool grade. (AH b3-4)

C. Physiology of Wool and Fiber

1. Development of mohair follicles in the skin of Angora goats. Analyses of histological preparations of biopsy samples of the skin of Angora goats are being continued at Beltsville, Maryland, in cooperation with the Texas Agricultural Experiment Station, McGregor, Texas. Current investigations will help to establish the range of medullated fibers per group of follicles. Information obtained earlier regarding medullated fibers was substantiated and it was again noted that this type of fiber is always present in the central primary follicles and in some of the lateral primary follicles. The diameters of the larger bulbs of Angora goat follicles measured 0.125 to 0.175 mm, while the dermal papillae observed in skin sections obtained during the summer period reached a length of 0.1 mm. (AH b5-1)

2. Sebaceous glands in sheep and goats. The sebaceous glands of sheep and goats function continuously from their inception at approximately 90 days of fetal life through maturity and old age. The glands associated with the primary follicles range in length from 0.250 to 0.375 mm in samples of Merino and Hampshire sheep; 0.350 to 0.450 in samples of Rambouillet rams as well as in the Texas Angora goats examined; and 0.250 to 0.315 mm in Toggenburg does.

Lecithin, or a closely related lipin, was found in the fat of the hypodermal and subcutaneous regions of the skin but was not evident in the sebaceous glands. Sebum was always present in all of the sebaceous glands. (AH b5-1)

3. Effect of season on mohair follicles. The incidence of medullated fibers differ in winter and summer samples taken from Angora goats at McGregor, Texas, and studied at Beltsville, Maryland. Counts of primary follicles made thus far indicate that more of the fibers in these particular samples, as observed within the skin are medullated in summer as compared with winter. There was a tendency for primary follicles to grow during the warm season and to rest during the winter. The secondary follicles of the Angora goat do not show a seasonal pattern of shedding and they resemble fine wool of sheep in that they lack medullation. For example, and this is irrespective of the time of year, a group consisting of 20 to 30 secondary follicles may show from 0 to 5 follicles in different stages of renewal. (AH b5-5)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Physiology of Reproduction

Hulet, C. V., Blackwell, R. L., Ercanbrack, S. K., Price, D. A., and Humphrey, R. D. 1962. Effects of feed and length of flushing period on lamb production in range ewes. J. Anim. Sci. 21(3), pp. 505-510 (AH b1-7).

Hulet, C. V., Blackwell, R. L., Ercanbrack, S. K., Price, D. A. and Wilson, L. O. 1962. Mating behavior of the ewe. J. Anim. Sci. 21(4), pp. 870-874 (AH b1-7).

Hulet, C. V. and Ercanbrack, S. K. 1962. A fertility index for rams. J. Anim. Sci. 21(3), pp. 489-493 (AH b1-7).

Hulet, C. V., Ercanbrack, S. K., Blackwell, R. L. and Humphrey, R. D. 1962. Effects of length of supplemental feeding prior to breeding on lamb production in Rambouillet range ewes. J. Anim. Sci. 21(3), p. 659 (Abstract) (AH b1-7).

Hulet, C. V., Ercanbrack, S. K., Blackwell, R. L., Price, D. A. and Wilson, L. O. 1962. Mating behavior of the ram in the multi-sire pen. J. Anim. Sci. 21(4), pp. 865-869 (AH b1-7).

Hulet, C. V., Ercanbrack, S. K., Price, D. A., Blackwell, R. L. and Wilson, L. O. 1962. Mating behavior of the ram in the one-sire pen. J. Anim. Sci. 21(4), pp. 857-864 (AH b1-7).

Hulet, C. V. and Foote, W. C. 1962. Observations in the ewe on the effect of ovum age on percent recovery and recovery site, and age of embryo on crown rump length. J. Anim. Sci. 21(3), p. 660. (Abstract) (AH b1-7).

Environmental Physiology

Cobb, E. H. and Morita, K. 1962. Use of Targhee rams for topcrossing in Hawaii. J. Anim. Sci. 21(3), p. 663 (Abstract) (AH b3-4).

Physiology of Wool and Fiber

Margolena, L. A. 1962. Sudoriferous glands of sheep and goats. Zeitschrift für mikroskopisch-anatomische Forschung, 69(2), pp.217-225 (AH b5-1).

Margolena, L. A. 1963. Ziehl-Neelsen's stain for skin sections to show wool and hair follicles. Stain Technology 38(3), pp. 145-148 (AH b5-1).

AREA 15: SHEEP AND GOATS--NUTRITION AND MANAGEMENT

Problem. The cost of feed is the largest single expense in the production of lamb meat and wool. Information that would increase the efficiency of feed utilization, reduce feed costs and increase productivity through better feeding practices would help the sheep producer meet the cost-price squeeze. Such information will come from basic studies of the development and function of the rumen, together with an understanding of how nutrients are metabolized in the animal. Such an understanding will enable sheep producers to modify and supplement rations in ways that will result in maximum production of desirable meat and wool. Much of the success or failure of sheep enterprises depends on production practices. Producers need better methods of animal management for the reduction of lamb mortality and disease and parasite losses, also procedures for handling ewes during breeding, gestation and lactation, as well as other labor-saving procedures and devices for the routine handling of sheep.

USDA PROGRAM

This is a continuing program conducted by biochemists, nutritionists, and animal husbandmen, involving basic nutrition and ruminant physiology studies, as well as application of known and new principles, in the development of better and more economic feeding practices of farm and range sheep. Basic studies on physiology and feeding practices and known and new principles in a number of fields are applied to the development of more productive management practices for farm and range sheep. These programs are carried on at Beltsville, Maryland; Dubois, Idaho; and College Station, Texas, in cooperation with other Division of ARS, and in formal and informal cooperation with State Agricultural Experiment Stations of Delaware, Idaho, Maryland, Montana, New York, Oklahoma, Texas, and Utah. Studies on ruminant bloat contribute to the North Central regional project on the chemistry and physiology of bloat.

The Federal scientific effort devoted to research in this area totals 3.6 professional man-years. Of this number, 1.1 are devoted to digestion and metabolism, 0.5 to forage evaluation and utilization, 1.2 to range and pasture management, 0.4 to management practices, equipment and facilities, and 0.4 to program leadership.

A grant involving Public Law 480 funds is in progress at the Ankara University, Ankara, Turkey, and is related to the methods of feeding and management on white muscle disease in lambs. The program is supported for 3 years (1963-1965) by $9333, equivalent in Turkish lire.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

1. Metabolic disorders. Basic and applied studies into the causes and prevention of urinary calculi were continued at College Station and Big Spring, Texas, with both steers and wethers. Two years' work of a three year study to compare the reactions of the steer and wether to factors involved in calculi formation at Big Spring indicates that different mineral ratios or mechanisms may be involved in calculi formation in the steer and wether; however, ammonium chloride seems to offer an effective means of control in both species.

Studies at College Station with wether lambs were designed to test the effect of pelleting, the size of the pellet, and the addition of sodium or potassium chloride to the diet. Pooled results of two years' work showed that 38 percent of the lambs fed the basal diet developed stones compared with 56 percent of the lambs fed pellets. The addition of one percent sodium chloride to the basal diet decreased the incidence from 38 to 25 percent. Sixty percent of the lambs affected were lost. The incidence was reduced to 10 percent with no clinical cases when 1 percent potassium chloride was used in place of the sodium chloride. (AH b2-1)

2. Feeding practices and procedures. Studies over a 5-year period at Beltsville, Maryland, have indicated that animals receiving alfalfa hay pellets ad libitum over a period of time become obese and have a shorter life span than normally fed animals. At autopsy in extremis or shortly after death, two common findings have been (1) an inflamation of the proximal duodenal mucosa and (2) a liver pathology, referred to, probably incorrectly, as chirrosis. To further study the pathology resulting from long-term pellet feeding or from resulting obesity, 11 animals ranging in age from 1 to 3 years were slaughtered and posted. One animal displayed the characteristic liver pathology and two had pneumonia. No gross pathology was observed in the remaining animals. Eight animals that had received chopped hay ad libitum for similar periods also were slaughtered and posted-none displayed any pathology. An experiment is now being designed to: (1) compare the life span of sheep fed alfalfa hay pellets ad libitum and at a low level of intake adequate to maintain normal growth and condition; (2) to distinguish between the effect of pellet consumption and the resultant degree of obesity on the life span; (3) to characterize any pathology resulting from alfalfa hay pellet feeding; and (4) to distinguish between the effect of pelleting alfalfa hay per se and the degree of obesity or any resultant pathology.

Two experiments were conducted at Beltsville to determine the effect of pelleting alfalfa hay on the ad libitum consumption of salt and of water by sheep. In the first experiment the effect of the physical state of the hay (ground vs. pelleted) on salt consumption was studied. Where salt was allowed free choice, salt and water consumption was greater on the pelleted

than on the ground hay diet. Where salt consumption was restricted, to normal intakes, the physical form of the hay had no effect on water intake. The second experiment was designed to determine the effect of level of feed intake on ad libitum salt and water consumption. Free choice salt consumption decreased as hay pellet intake increased but water intake increased as the pellet intake increased. It would, therefore, appear that level of intake, which, under practical feeding conditions, is greater when pelleted forages are fed, is probably a greater stimulus to increased water consumption than any increase in salt consumption that may accompany the feeding of pelleted forage.

Trials over an 18 month period at Beltsville to compare the wool production of sheep fed pelleted alfalfa with that of sheep fed chopped alfalfa have been completed. Preliminary results indicate that wool production is similar when equal amounts of pellets and chopped hay are consumed. (AH b2-5)

The response of 965 Rambouillet, Targhee and Columbia ewe lambs subjected to three methods of feeding, using two qualities of alfalfa hay, was investigated during 1961 and 1962 at Dubois, Idaho. The five winter feedlot treatments (112 day period) were: (1) high quality baled alfalfa hay fed on the ground at a rate of 4.5 pounds per head, per day; (2) self-fed high quality chopped-hay pellets (average daily consumption 5.7 pounds); (3) self-fed low-quality chopped-hay pellets (average daily consumption 5.6 pounds); (4) hand-fed high-quality chopped hay pellets at a rate of 3.4 pounds per head, per day; and (5) hand-fed low-quality chopped-hay pellets at a rate of 3.4 pounds per head, per day. The pellets were fed in troughs or self-feeders. The average daily gain per head, per day, was 0.18 pound for the baled hay group; 0.58 pound for the self-fed high quality hay pellets group; 0.55 pound for the self-fed low quality hay pellet group; 0.31 pound for the hand-fed high quality hay pellet group; and 0.27 pound for the hand-fed low quality hay pellet group. Grease fleece value was significantly higher for the self-fed pellet groups than for the other groups and was slightly higher for the hand-fed pellet groups than for the baled hay group.

The relative merit of feeding a 100 percent ground alfalfa hay pellet compared with various rations of barley and alfalfa for the fattening of feeder lambs for slaughter was investigated at Dubois, Idaho. The lambs were about 60 days of age upon entering the feedlot and the rations were self-fed for 42 days. Lambs fed the 100 percent ground alfalfa hay pellet had the lowest feed cost per pound of gain but the highest shrinkage in body weight in transit to market at Ogden, Utah. The net return per lamb was $2.00 for those receiving 100 percent alfalfa hay pellets, $2.14 for those receiving a 50-50 ratio of alfalfa to barley, and $2.27 for those receiving a 25-75 barley-alfalfa-pellet.

Winter feeding trials were conducted with 540 ewes at Dubois, Idaho, in an attempt to find a more economical and time saving method of feeding pregnant ewes in the winter feed lots. Lot 1 was fed 5.8 pounds of baled hay on the

ground, lot 2 was fed alfalfa pellets according to National Research Council recommendations, lot 3 was fed pellets at 95 percent of the NRC recommendations, and lot 4 at 90 percent of the NRC recommendations. Method of feeding and amount of feed had no apparent influence on body weight gains, percent of live lambs born or on birth weight of the lambs. Butterfat determinations on samples of milk from 44 lactating ewes from the various groups did not indicate any depression in butterfat content due to the feeding of pellets.

3. Studies on nutritive requirements of sheep. The potassium requirement of the growing lamb was investigated in cooperation with the Division of Nutrition, Food and Drug Administration at Beltsville, Maryland. Two lambs, a ram and a ewe, weighing about 50 pounds, were fed 0.0, 0.3, 0.6 or 0.9 percent potassium as potassium acetate as a supplement to a synthetic diet containing casein, sucrose, hydrogenated vegetable oil, celluflour, a salt mixture, and vitamins A, D, E, and the major members of the B complex. The diets and tap water were offered free choice. After 7 weeks, there was a weight loss at all levels of potassium supplementation of 7 to 12 pounds per lamb. Because there was no graded response in weight change over the levels of potassium supplementation, it was concluded that the poor response was due to nutritional inadequacies other than potassium level. One lamb died during this period and a second was sacrificed in extremis. No gross pathological lesions attributable to potassium inadequacy were observed; histopathological determinations have not been completed. In the ensuing three weeks, the sucrose of the basal diet was replaced with equal parts of cornstarch and glucose monohydrate and solka-flock replaced the celluflour. Gains per lamb in the 0.6 and 0.9 percent potassium groups ranged from four to nine pounds over this period while there were losses of from one to five pounds per lamb in the 0.0 and 0.3 percent potassium groups. The experiment was terminated by necropsy of the remaining lambs. There was no gross pathology apparent at any level of K supplementation. Histopathological determinations on the tissues have not been completed. (AH b2-5)

An experiment was conducted in 1963 at Dubois with 140 ewes and their 200 suckling lambs to determine the effect of different methods of feeding ewes after lambing as measured by body weight of lambs as they left the mixing pens to go on the range at an average age of 32 days. The effects of sex, type of birth and rearing, age of dam, birth weight, and age in days were held constant. The ewes were fed in one group prior to lambing. After lambing they were divided into four treatment groups and fed as follows: lot 1, alfalfa hay plus 2 pounds of oats; lot 2, alfalfa pellets plus 2 pounds of oats; lot 3, alfalfa hay, no grain; and lot 4, alfalfa pellets, no grain. The average body weight of the lambs weighed out of the mixing pen was 27.7 pounds. Lots 1, 2, and 3 were 3.0, 1.4, and 0.9 pounds heavier than lot 4 in body weight indicating in this trial an advantage for feeding grain after lambing. The weaning weights of these lambs will be compared as the information becomes available. (AH b3-9)

The effect of sex and initial weight on the gain and feed efficiency of fattening feeder lambs receiving a high concentrate and a standard fattening diet was studied at El Reno, Oklahoma. The high concentrate diet contained approximately 83 percent concentrates and the normal diet, 50 percent. The base grain was milo. Wether lambs in each weight group fed the high concentrate diet gained more rapidly and required less feed per hundred weight than the lambs on the standard diet. Ewe lambs varied in their response to the diets. The heaviest ewe lambs fed the high concentrate diet gained more rapidly on less feed, but the reverse was true with the light lambs. Within weight groups and diet groups, wether lambs did not consistently gain more rapidly than ewe lambs; however, in three cases out of four, they required less feed per hundred pounds of gain. Considering gain based on body weight, there was little difference in average daily gain of the three weight groups. The heavier lambs gained considerably faster, but the difference was due mostly to greater body size. (AH b3-7)

B. Forage Evaluation and Utilization

1. Forage intake by range sheep. Quantity and quality of the nutrient intake of sheep grazing on the U. S. Sheep Experiment Station, Dubois, Idaho, fall, winter, spring, and summer ranges are being investigated by the use of esophageal fistulated sheep to obtain dietary intake and bagged sheep for total feces collection. Digestion trials were conducted at early, intermediate and late periods of the summer season on the mountain summer range. Samples obtained from these trials are under laboratory analyses. Preliminary results of the chemical analyses of the esophageal fistula samples indicated that the crude protein content declined from 16.95 percent to 14.13 percent from period one to period three and that the crude fiber content increased from 18.53 percent to 19.36 percent during the same period. Forage samples also have been collected on the spring, fall and winter ranges using esophageal fistulated sheep and are being subjected to laboratory analyses. (AH b3-9)

C. Range and Pasture Management

1. Grazing practices. Studies on the effects of grazing sheep and cattle together have been continued at Beltsville. The design of this experiment has been described in previous reports - the only difference is that the ladino clover has died out leaving an almost pure stand of orchard grass. The trial was started on April 11 of this season. Through July 3 (83 days) sheep grazing alone averaged 0.35 pounds per day which was significantly less than for sheep grazing with cattle, 0.39 pounds, per day. Stocking rate had no significant effect on sheep gains and the average gain of the sheep grazing with cattle at the 1:1 ratio was not significantly different from those grazing at the 1:5 ratio. Preliminary investigations have not indicated that the helminth level of the sheep grazed alone is different from those grazed with cattle. The animal phases of digestibility and organic matter intake studies have just been completed; however, the analytical work has not been completed. (AH b3-10)

2. Management in relationship to parasitism. Studies on the effects of management practices in relationship to parasitism and gains of lambs have been continued at Beltsville in cooperation Animal Disease and Parasitism Division. Four management systems have been studied in 1963. These include, (1) early weaning of lambs (about 60 days of age and the lambs grazed on clean pastures from the start of the experiment; (2) lambs separated from the ewes at 8:00 a.m. and grazed separately in clean pastures until 4:00 p.m. and then allowed to nurse the ewes in drylot overnight; (3) ewes and lambs grazed on contaminated pastures, plus therapeutic treatment with N. F. phenothiazine when indicated by fecal egg counts; (4) ewes and lambs grazed on contaminated pastures, plus therapeutic treatment with thiabendazole when indicated by fecal egg counts. Lambs in bands II, III, and IV were weaned at 120 days of age. Average daily gain of the lambs from April 10 through June 19 (when all lambs were weaned) was 0.49 pounds for the early weaned lambs, 0.37 pounds for the lambsgrazed separately from their dams, and 0.43 and 0.40 for the two groups grazed on contaminated pastures. Fecal egg counts on July 3 revealed that the early weaned lambs had three haemonchus eggs per gram, the lambs grazed separately from their dams had 16, while those grazing on contaminated pastures had 1038 and 865 eggs per gram, respectively, for bands III and IV. (AH b3-11)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Digestion and Metabolism.

Crookshank, H. R. 1962. Ovine urinary calculi and pelleted rations. J. Anim. Sci. 21(4), p. 993 (Abstract) (AH b2-1).

Noble, R. L., Ely, D. and Waller, Jr. G. 1963. High concentrate ration for fattening feeder lambs; the effect of sex or sex condition and initial weight on gain and feed efficiency. Oklahoma M. P. 70, pp. 5-14 (AH b3-7).

Range and Pasture Management

Lindahl, I. L., Kates, K. C., Turner, J. H., Enzie, F. D. and Whitmore, G.E. 1963. Effect of management systems on the growth of lambs and development of internal parasitism. I. Dry lot vs. two pasture rotation systems. The Journal of Parasitology 49(2), pp. 209-217 (AH b3-11).

AREA NO. 16: SWINE--BREEDING

Problem. Improvements in the heredity of swine depend on the intensity and accuracy of selection practiced in choosing breeding animals and on the choice of a mating system that maximizes the rate of genetic improvement. Crossbreeding swine for the production of market animals has so proved its value that over 90% of the pigs marketed in the United States are currently some kind of crossbreds. Research in swine breeding thus is faced with the dual challenge of developing foundation seed stock populations that yield maximum improvement for commercial production and also devising methods that fully utilize the genetic potential of available seed stocks for further increases from heterosis and hybrid vigor generally shown by crossbred pigs. It is essential that experimental work continue the development of genetic facts and practical methods that breeders can use to develop better and more efficient seed stock strains. Particular effort is needed on effective genetic means for efficient production of pork with more lean and less fat without sacrificing gains in other production traits.

USDA PROGRAM

This is a continuing program of basic and applied research conducted by geneticists and animal husbandmen to elucidate genetic principles and develop effective breeding systems that will result in further increases in the efficiency of swine with respect to productivity and carcass value. It is a coordinated research effort between several State Agricultural Experiment Stations and the USDA. Research is in progress at Beltsville, Maryland, cooperatively with the Montana Agricultural Experiment Station at Miles City, Montana, and at the Regional Swine Breeding Laboratory with headquarters at Ames, Iowa. The Regional Laboratory includes cooperative projects at State Agricultural Experiment Stations in Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, Oklahoma, South Dakota, and Wisconsin. Investigations on genetic principles, selection, and breeding systems include work with swine and also with laboratory animals on important performance traits, their heritabilities, and their phenotypic and genetic correlations. The results of such studies provide the basis for emphasis given to different complex traits and the underlying factors in evaluating different systems for achieving genetic changes. Traits of major interest include productivity of dam, viability, growth rate, feed efficiency, carcass composition, and quality of meat.

A cooperative project with the Food and Drug Administration was started in 1963 to investigate the response of a herd of miniature swine to further reduction in body size from selection and the usefulness of this strain of swine for toxological tests as well as basic studies in nutrition and genetics.

The Federal scientific effort in this area totals 9.5 professional man-years. Of this number, 0.0 is devoted to genetics and interrelations of performance traits, 7.4 to selection and breeding systems, and 2.1 to program leadership.

A grant with the College of Agriculture, Poznan, Poland, provides for investigations on red blood cell and serum antigens to establish the mode of inheritance and relative frequencies of these antigens in certain breeds of swine. Its duration is for five years, 1962-1966, and involves PL-480 funds.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits

1. Genetic and phenotypic parameters. A study involving 3,871 litter records collected at three stations during the period 1944 to 1958 showed that approximately 15% of the total variances in litter size at birth and at weaning and about 30% of the variance in litter weight at weaning could be ascribed to the combined effects of differences between stations, breeds, years, seasons, farrowing history, age and inbreeding of sow, and inbreeding of litter. Heritabilities based on daughter-dam regressions of data corrected for the various environmental effects considered in the analysis were estimated at .08 ± .04 for litter size at birth, .07 ± .04 for litter size at one day of age, .14 ± .04 for litter size at 56 days, .22 ± .04 for litter weight at 56 days, and .09 ± .04 for litter size at 154 days. Repeatabilities estimated from intraclass correlations of records from the same sow were lower for three of the five traits than the corresponding heritabilities. These results suggest compensatory carryover effects tending to make successive litters out of the same sow more unlike than they would have been otherwise. It was also found that daughters from litters of one to five pigs had litters which were, on the average, larger than those of daughters from litters of six to ten pigs. (AH a1-4)

At the Iowa Station, data from 271 test groups fed under Record-of-Performance conditions on one farm and data from 248 litters raised in an irradiation experiment on another farm were analyzed (1) to evaluate the effects of certain environmental factors on growth rate and feed efficiency, (2) to obtain estimates of heritability and genetic and phenotypic correlations for these traits, and (3) to study the effect of paternal irradiation. About half of the boars in the irradiation experiment were treated locally at the testicle with 300 r. X-irradiation at about six months of age. Heritabilities based on the variance between litter means were estimated at .22 and .55 for daily gain, at .54 for 154-day weight, and at .52 and .38 for feed efficiency. Genetic correlations obtained for daily gain with feed requirements were -.643 and -.555. Corresponding phenotypic correlations were -.541 and -.085. Intraclass correlations between paternal half-sib litters from irradiated sires were smaller for all traits than those from control sires. The respective correlations were .183 and .320 for daily gain, .184 and .304 for 154-day weight, and .115 and .206 for feed efficiency. (AH a1-4)

Heritabilities obtained by the paternal half-sib method from data collected on 1,715 pigs belonging to the miniature herd at the Hormel Institute, Austin, Minnesota, were .53 ± .36 for 56-day weight, .43 ± .36 for 112-day

weight, .45 ± .38 for 154-day weight, and .46 ± .34 for daily gain from 56 to 154 days of age. Pooled estimates obtained by paternal half-sib correlations and two methods of offspring-parent regression were considerably smaller; i.e., .08 ± .059 for 56-day weight, .16 ± .066 for 154-day weight, and .15 ± .059 for daily gain. (AH a1-17)

Genetic correlations obtained for weaning weight with post-weaning growth rate at the Minnesota Station were .58 ± .30 from an analysis of variance and covariance, .62 from regression of offspring on sire, and .92 from intrasire regression of offspring on dam. Heritability estimates were .14 ± .11, .07 ± .06, and .26 ± .07, respectively, for weaning weight, and .26 ± .10, .15 ± .11, and .34 ± .69 for daily gain. The corresponding pooled heritabilities were .18 and .31, while the pooled genetic and phenotypic correlations among the two traits were .69 and .37, respectively. Data on 2,693 pigs from 357 gilt litters by 129 sires of the Minnesota No. 2 and No. 3 breeds were available for the above study. (AH a1-17)

In another study at Minnesota, data from 56 sires with both purebred and crossbred progeny were used to estimate the covariance of sire effects in purebred and crossbred populations of the Minnesota breeds of swine. Estimates were -2.42 ± 3.67 for weaning weight, .0040 ± .0018 for daily gain, and .0005 ± .0007 for backfat probe. These findings indicate that if mass selections were practiced in both sexes of both purebred populations that make up a cross, crossbreds produced by animals thus selected would show a 17% decrease of the amount reached for when selecting for weaning weight, and a 42% and 7% increase of the amount reached for when selecting for daily gain and backfat probe, respectively. (AH a1-17)

At the Oklahoma Station, data on 11,876 pigs from two experimental herds at that Station and data on 6,828 pigs from one herd in Iowa were studied to estimate the relative importance of different causes of variation in nipple number. The average number of nipples per side was 6.22 and the standard deviationwas .71. Sex, litter size, and parity of dam were found to have little influence on nipple number. There was evidence of breed differences, but no indication of influence from inbreeding or heterosis. The average difference in nipple number between the right and left side was small and indicated that the observed asymmetry was more or less random for each pig. About 28% of the variance of nipple number per side was attributable to additive gene action, 3% to genetic differences in maternal influence, 10% to environmental factors affecting both sides of the same pig alike, and about 59% to environmental factors affecting the two sides of the same pig differently. At the Missouri Station, heritability of nipple number was estimated at .46. Sex of the pig was not important and there was no evidence of maternal influence when reciprocal crosses were compared. (AH a1-6 and a1-8)

A study of sexual maturity as measured by age at first estrus for 180 gilts in a breeding experiment at Beltsville showed crossbred gilts averaging about 17 days younger and about 16 pounds heavier at puberty than contemporary straightbred gilts in two strains derived from the same sources as

those used to produce the crosses. The averages for age at first heat for LL, BB, BL, and LB gilts were 212, 206, 196, and 189 days, respectively. The pooled standard deviation within group was 30 days. Straightbreds and crossbreds produced by the two groups of straightbred dams showed an average difference of about six days in age at puberty, indicating that genetic differences in maternal effects may be responsible for some of the variations found in age at first heat. The fractions of variance accounted for by the combined effects of age at first heat, weight at first heat, and number of days from age at first heat to conception varied from about 3% to 33% for litter size at birth and from about 10% to 22% for litter weight at birth. These results emphasize the need for more information about the factors primarily responsible for the variation in age of gilts at puberty and in their subsequent productivity as dams. (AH a1-13)

An analysis of data from a selection experiment for high and low fatness in Duroc and Yorkshire swine at Beltsville indicates that inbreeding effects on backfat thickness and post-weaning growth rate may vary with the direction in which selection is practiced and be influenced by the genetic makeup of the particular stock from which selected lines are being developed. In the Duroc breed, inbreeding decreased the rate of fat deposition in the high-fat line and increased it in the low-fat line, whereas for the high- and low-fat Yorkshire lines the reverse situation was observed. Selection for high and low fatness also showed a differential inbreeding effect on daily gain for direction of selection pressure which was similar for both breeds. Both backfat thickness and daily gain tended to decrease with inbreeding in the unselected Duroc and Yorkshire control lines. Partial regression coefficients on date born showed earlier born pigs in the three Duroc lines averaging fatter and slower growing than pigs born later in the season, whereas in the three Yorkshire lines the reverse situation was found for both traits. In both breeds, heavier pigs at weaning averaged lower in backfat thickness and grew faster after weaning than the lighter ones. These results for post-weaning growth rate are in agreement with results reported by other workers. (AH a1-12)

2. Pilot experiments. Genetic correlations between litter size and growth rate in mice were studied at the Minnesota Station. Estimates of genetic parameters were 0.306 ± 0.097 for the additive genetic variance of growth rate, 0.29 ± 0.107 for the additive genetic variance of litter size, and 0.046 ± 0.229 for the additive genetic covariance between litter size and growth rate. The heritability of litter size was 0.11 ± 0.041 and of growth rate 0.214 ± 0.068. The estimate of 0.153 for the genetic correlation between the two traits was not significantly different from zero. The results suggest that correlated response, if any, will be in the direction of larger litters. The actual genetic change in average litter size during 13 generations of selection was 0.082 ± 0.035 mice per generation in terms of linear regression. (AH a1-17)

In another study at the Minnesota Station, selection for post-weaning growth rate in mice has continued to be effective through the 19th generation. No

significant deviation from linearity has been found in the regression of response to selection on generation time. Improvement in the cross of the selected population with the unselected control has been about one-half that of the selected population. This is to be expected if genes are largely additive in their effect. Estimates of the genetic correlation between growth and litter size have been positive. In agreement with this, litter size has increased in the population selected for growth by about 1.6 mice per litter. (AH a1-17)

B. Selection and Breeding Systems

1. Selection for single traits. Selection based on backfat thickness has been carried through eight generations in the high- and low-fat Duroc lines and through six generations in the high- and low-fat Yorkshire lines. Backfat thickness at 175 pounds averaged 2.03, 1.20, and 1.56 inches for eighth generation high-fat, low-fat, and control line Duroc pigs, and 1.43, 1.12, and 1.30 inches for sixth generation high-fat, low-fat, and control line Yorkshire pigs. The means for the selected lines differ only slightly from their respective means in 1961. However, in each case the differences pointed in the direction in which selection was practiced, with the control line in each breed averaging slightly higher in 1962 than in 1961. In Durocs, post-weaning daily gain continued to average somewhat higher in the control line than in the selected lines, the respective averages for high-, low-, and control line pigs being 1.46, 1.40, and 1.49 pounds. Daily gain for the three Yorkshire lines averaged 1.25, 1.21, and 1.30 pounds, respectively.

Averages based on eight years' data for the Duroc lines and on six years' data for the Yorkshire lines show that in the Duroc breed the low-fat line was equal or superior to the high-fat line in all traits studied. The control line in turn excelled the two selected lines in conception rate, in litter size, and in litter weight at birth and at weaning, and was intermediate with respect to percent stillborn pigs and pig weight at birth and at weaning. While dam's weight at breeding differed little between lines, high-fat gilts gained about 41 pounds less weight during the gestation period than low-fat gilts with control line gilts intermediate between the two selected lines. During the suckling period, high-fat gilts continued to put on weight at the rate of about .38 pound daily, compared with .07 pound gain for low-fat gilts and a .14 pound loss for control line gilts. Thus, it appears that in Durocs selection for high fatness has tended to modify the growth pattern with the result that high-fat animals average lower in mature body weight than those in the low-fat control lines. Thus far, selection in the Yorkshire breed appears to have had little or no effect on preweaning growth rate or mature body weight. The three Yorkshire lines also have differed only slightly with respect to litter size, litter weight, and pig weight at birth and at weaning. Conception rates, on the other hand, averaged about 10% less in low-fat than in high-fat or control line gilts.

Carcass data obtained on samples of pigs continued to show rather marked differences between high- and low-fat pigs, with controls generally intermediate between the selected lines in both breeds. Eighth generation high-fat, low-fat, and control line Durocs averaged 2.43, 1.41, and 2.06 inches in backfat thickness; 27.8, 30.1, and 28.8 inches in length of carcass; 2.73, 3.99, and 3.24 square inches in loin eye muscle area; 35.4, 40.8, and 37.8% in yield of lean cuts; 19.6, 13.2, and 16.7% in yield of fat cuts; and 11.7, 9.7, and 10.6% in yield of bacon. Sixth generation high-, low-, and control line Yorkshire pigs averaged 1.90, 1.28, and 1.26 inches in backfat thickness; 30.9, 31.0, and 31.1 inches in length of carcass; 3.30, 4.28, and 3.47 square inches in loin eye muscle area; 38.2, 41.2, and 39.3% in yield of lean cuts; 15.7, 12.6, and 14.7% in yield of fat cuts; and 11.2, 10.0, and 10.5% in yield of bacon.

Generation means obtained for the three Duroc and three Yorkshire lines after adjusting each individual record to zero inbreeding, average weaning weight, and average day of year born of respective control line pigs as well as for sex effects to the average of boars, barrows, and gilts showed that transformation of the original backfat measurements to logarithms did not remove any of the asymmetry in the responses of backfat thickness shown by the high- and low-fat Duroc pigs. Thus, the relatively greater effectiveness of selection for high than for low fatness in Durocs can hardly be attributed to the existence of genes with multiplicative effects on backfat thickness. (AH a1-12)

At the Missouri Station, three generations of selection for low backfat thickness in Polands have been completed with replications in the spring and fall. Boars and gilts in the spring line now have .08 and .16 inches less backfat than the foundation animals. In the fall line, backfat thickness has been reduced by .16 and .24 inches. There has been a decline in daily gain in both lines even though animals selected for breeding were above the average of the group from which they were selected. Data on ovulation rate and embryonic death loss in gilts bred and slaughtered and in gilts farrowing and weaning litters suggested that the genetically leaner gilts farrowed and weaned larger and heavier litters than the fatter ones. (AH a1-6)

Selection for low backfat thickness was continued at the South Dakota Station with a line of Duroc pigs. Although parents of 1962 pigs averaged .17 inches less fat than the group from which they were selected, no reduction was noted in average backfat between the 1961 and 1962 pig crops. (AH a1-9 rev. 2)

The effectiveness of selecting for small size at 154 days was studied in the herd of miniature pigs at the Hormel Institute, Austin, Minnesota. Data were available for 1,715 pigs from 640 litters farrowed during the period 1950 to 1958. Selection differentials averaged 9.1 pounds for females and 15.6 for males. Body size decreased at the average rate of

slightly over three pounds per year, compared with an expected decrease of about two pounds. Response to selection for small size has been progressive and constant. (AH a1-17)

2. Selection for combining ability. In the Miles City project, litter size at birth averaged the same for single cross as for control strain litters (i.e., 10.0 pigs), but single crosses exceeded controls by 0.8 pig or 10.0% in litter size at weaning, by 108 pounds or 46% in litter weight at weaning, and by 9.2 pounds or 31% in pig weight at weaning. The advantages for crosses in litter size at weaning were of about the same magnitude as those found in the fifth selection cycle, but those in litter weight and pig weight at weaning were considerably larger for sixth than for fifth cycle pigs. Plans in the Miles City project are to test the Montana No. 1 and Yorkshire "Select" strain in crosses with one another as well as in reciprocal crosses with the Montana No. 1 control strain. These crosses are to serve as a basis for evaluating more critically the effectiveness of reciprocal recurrent selection as practiced in this project. (AH a1-11)

3. Development and evaluation of inbred lines and crosses. Mainly crossline litters among lines 7, 11, and 14 were produced in 1962 in the rapid inbreeding project at the Michigan Station. Line 11 has been outstanding in fertility as an inbred line of Yorkshires. The foundation dam had 13 litters in 14 seasons. The eight inbred litters averaged 6.8 pigs weaned. The five outbred litters averaged 9.2 pigs. More inbred sows failed to conceive than outbreds. (AH a1-14)

The use of close inbreeding for evaluating the performance of and selecting among several samples of the Yorkshire breed has continued at the South Dakota Station. Only three of ten breed samples remain. These have survived two initial generations of close inbreeding, interline crosses, and three more closely inbred generations. Lines are different in conformation as well as performance and carcass traits. Rapid inbreeding among Yorkshire lines has resulted in opportunities for early between-line selection. (AH a1-9)

Although inbreeding effects on weaning weight in cattle have been reported to be higher in females than males, an analysis of data from the litters produced from 1956-1963 in the swine breeding project at Michigan indicated that the inbreeding effect on 154-day weight in swine is greater in males than females. Each 10% increase in inbreeding reduced 154-day weight by 8.8 pounds in barrows and 6.4 pounds in gilts. (AH a1-14)

4. Environmental influences as related to performance. Pigs from the 1962 spring litters at the Michigan Testing Station gained .10 pounds per day faster, required .31 pounds less feed to make a pound of gain, had .06 inches more backfat, and had .16 square inches smaller loin eyes than fall litters. Sex differences between 30 pairs of full sibs indicated that barrows gained 0.21 pounds faster per day, had 0.12 inches more backfat,

were 0.13 inches shorter, had 0.52 square inches less loin eye area, and had 1.1% less ham and loin than gilts. (AH a1-14)

5. Gene pools. The "old" breed gene pool (Line Y) at Lincoln, Nebraska, includes contributions from the following breeds: Berkshire, Chester White, Duroc, Hampshire, Landrace, Poland, Spotted Poland, Tamworth, Welsh, Wessex Saddleback, and Yorkshire. The Large Black and Hereford will be added in 1963. The variation in conformation and color remains high. A second gene pool comprised of the newer breeds of swine will be started in 1964. Breeds to be used include: Beltsville No. 1, Beltsville No. 2, Lacombe, Landrace-Large Black, Maryland No. 1, Montana No. 1, Minnesota Nos. 1, 2, and 3, Palouse, and San Pierre. Small nucleus herds of Duroc, Hampshire, and Yorkshire are maintained to supply breeding stock for nutrition research at the Nebraska Station. Replacements are selected for 140-day weight and backfat thickness. Carcass data from nutrition research will allow a continuing general assessment of the carcass merit in other herds. (AH a1-7)

6. Crossbreeding and heterosis. The importance of breed of dam in the production of crossbred hogs was studied at the Missouri Station. Litter size, pig, and litter weight at different ages, backfat probe, body length, and heart girth at 200 pounds were compared in reciprocal crosses of the Landrace X Poland and Duroc breeds and crosses. The crossbred litters from Landrace dams and Poland sires were 0.8, 1.3, and 1.3 pigs larger at birth, 56 days and 154 days, respectively, than in the reciprocal cross. ($P < .01$). Landrace sows produced litters 0.4 pounds lighter at birth, 46.4 pounds heavier at 56 days ($P < .05$), and 170.4 pounds heavier at 154 days ($P < .005$). No significant differences between the reciprocal crosses of these two breeds were found in average fat thickness at shoulder, hip, and ham or in body length and heart girth measurements.

Litter size at birth, 56 days, and 154 days was 2.5, 2.2, and 2.1 pigs larger ($P < .005$) in the L X P sows and Duroc boar cross, than in the reciprocal. Pigs from the L X P sows were also heavier at all ages and in total litter weight. Pigs from Duroc sows had thicker backfat probes at each location (nonsignificant). Pigs from the Duroc sows had shorter bodies ($P < .005$). Significant differences were not found in heart girth. (AH a1-6)

Rotation-breed-line crossing of the Hampshire, Duroc, and Yorkshire breeds at South Dakota was continued into the 15th generation. This herd, utilizing boars produced in the lines at Brookings, has been "cleaned-up" through SPF procedures. Second generation pigs were 30% heavier at 56 days and reached market weight three weeks earlier than pigs of the same breeding previously. Thus far, there seems to have been a marked reduction in environmental stress by the SPF process. This suggests an urgent need for more information about the use of SPF animals in studies of swine genetics and the application of results from such herds to usual production methods. (AH a1-9)

The effects of heterosis on age at puberty, ovulation rate, and percent embryo survival in gilts bred at a constant sexual age (second estrus) were studied at Nebraska. Yorkshire, Duroc, and reciprocal crossbred gilts from the 1962 spring pig crop were used. The progenies of five Duroc and five Yorkshire sires were represented. Each sire contributed both purebred and X-bred offspring. Age and weight at puberty were both influenced by heterosis. The crossbred gilts were 4.2 days younger and 9.2 pounds heavier at puberty than the purebred gilts ($P < .05$). Sire within breed of sire was also a significant source of variation in age at puberty. The average ages and weights at puberty ranged from 203 to 220 days and 230 to 273 pounds for the Yorkshire sire groups, and from 202 to 226 days and 250 to 256 pounds for the Duroc sire groups. The effect of heterosis on ovulation rate was negligible; the crossbred gilts averaged only .3 more corpora lutea at second estrus than the purebreds. However, breed of sire, sire within breed of sire, and breed of dam were all important sources of variation in ovulation rate. The purebred and crossbred progeny of Yorkshire sires averaged 15.4 corpora lutea at second estrus as compared to 16.8 for similar progeny of the Duroc sires ($P < .01$). The average numbers of corpora lutea ranged from 13.4 to 17.0 for the Yorkshire sire groups, and from 12.9 to 20.8 for the Duroc sire groups ($P < .01$). The progeny of Duroc dams shed one more ovum at second estrus than the progeny of Yorkshire dams, 16.6 vs. 15.6 ($P = .12$). The flushing treatment used stimulated increased ovulation rates in all breeding groups. However, the magnitude of response was closely associated with breed of dam. The purebred and crossbred gilts from Duroc dams showed a response of 2.6 ova to flushing as compared to only a .5 ovum increase in the gilts from Yorkshire dams ($P < .05$). (AH a1-7)

C. Performance and Progeny Testing

Performance and progeny test records on sets of boars from three lines in three different breeds were studied at the Oklahoma Station. The results indicated the usefulness of a herd testing program for the evaluation of individual performance and also of a progeny testing program of selected sires to improve the efficiency of overall selection. Individual performance, pedigree, and family performance are extremely useful in the initial selections of young herd sires. Although these are correlated to the breeding values of these individuals for heritable traits, they are not perfect indicators of breeding value. The progeny test gives new information about breeding value which will make the overall testing and selection program more complete and more reliable. In such a program, it is necessary to test a much larger number of boars than is actually needed for service in order to permit selection on performance test results. Similarly, more boars must be progeny tested than are actually needed for service to permit more opportunity to select on progeny test results and also to increase the chances of locating the really superior sires. (AH a1-8)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Genetics and Interrelations of Performance Traits

DeBaca, R. E. 1962. Iowa swine testing station and the pork producer. Iowa State Univ. Coop. Ext. Serv. Pamp. 291. (AH a1-4)

Dettmers, A. E. 1962. Selection for small size in swine. Ph. D. Thesis. Univ. of Minn. Libr. St. Paul. (AH a1-17)

Enfield, F. D., and Rempel, W. E. 1962. Covariance of sire effects in purebred and crossbred populations of swine. (Abs.) J. Animal Sci. 21:971. (AH a1-17)

Foster, J. R., Garwood, V. A., Jones, H. W., and Pickett, R. A. 1962. Comparison of protein supplements for swine with different cross-breeding programs. Ind. Agr. Exp. Sta. Res. Prog. Rept. 38. (AH a1-3)

Kearns, D. S. 1963. Genetic parameters within an inbred strain of Chester White swine. M.S. Thesis. Purdue Univ. Libr. Lafayette. (AH a1-3)

Kumaresan, Periana. 1963. The inheritance of nipple number in swine. M.S. Thesis. Univ. of Mo. Libr. Columbia. (AH a1-6)

Magee, W. T. 1962. Relationship between daily feed consumption and feed efficiency. J. Animal Sci. 21:880-882. (AH a1-14)

Nelson, L. A. 1962. Relationships between body length and other carcass measurements of pigs. M.S. Thesis. Univ. of Nebr. Libr. Lincoln. (AH a1-7)

Nelson, L. A., and Sumption, L. J. 1962. Relationships between length and other carcass measurements. (Abs.) J. Animal Sci. 21:984. (AH a1-7)

Park, Young, Il. 1962. Heritabilities and genetic correlation between growth rate and feed efficiency in swine. M.S. Thesis. Iowa State Univ. Libr. Ames. (AH a1-4)

Rahnefeld, G. W., Boylan, W. J., and Comstock, R. E. 1962. Genetic correlations between growth rate and litter size in mice. Can. J. Genet. Cytol. 4:289-295. (AH a1-17)

Sumption, L. J. 1962. A proposed revision of the R.O.P. program. Inbred News. 12(3):4-7. Apr. (AH a1-17)

Urban, Jr., Willard E. 1963. Genetic and environmental aspects of litter size in swine. Ph. D. Thesis. Iowa State Univ. Libr. Ames. (AH a1-4)

Vogt, D. W., Comstock, R. E., and Rempel, W. E. 1963. Genetic correlations between some economically important traits in swine. J. Animal Sci. 22:214-217. (AH a1-17)

Waltz, F. A. 1963. Genetic parameters within two breeds of purebred swine. M.S. Thesis. Purdue Univ. Libr. Lafayette. (AH a1-3)

Ward, Harold K. 1962. Genetic relationships of weaning weight with post-weaning growth in swine. M.S. Thesis. Univ. of Minn. Libr. St. Paul. (AH a1-17)

Ward, Harold K., Rempel, W. E., and Enfield, F. D. 1962. Genetic correlations between weaning weight and daily gain in pigs. (Abs.) J. Animal Sci. 21:976-977. (AH a1-17)

Whatley, Jr., J. A. 1963. Performance and progeny tests for evaluating boars. Feeding and Breeding Tests. 37th Ann. Livestock Feeders Day Rept. Apr. 20, 1963. MP-70:36-41. (AH a1-8)

Willham, R. L. 1963. The covariance between relatives for characters composed of components contributed by related individuals. Biometrics. 19(1):18-27. (AH a1-4)
Willham, R. L., and Whatley, Jr., J. A. 1963. Genetic variation in nipple number in swine. Z. Tierz. Zucht. Biol. (In press.) (AH a1-4)

Selection and Breeding Systems

Gray, Richard C. 1963. Efficiency of selection for thinner backfat at different weights in swine and the relationship of backfat thickness to performance of sows. M.S. Thesis. Univ. of Mo. Libr. Columbia. (AH a1-6)
Lasley, John F. 1963. Genetics of Livestock Improvement. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. (AH a1-6)
McCarty, J. W. 1962. Pointers in breeding for production. Fifth Ann. Swine Day Rept. S. Dak. Agr. Exp. Sta. (AH a1-9)
McCarty, J. W. 1963. Progress report on the establishment of a SPF herd at the Eureka Station. Sixth Ann. Swine Field Day Rept. S. Dak. Agr. Exp. Sta. AS Mimeo. 63-10. (AH a1-9)
McCarty, J. W. 1962. Swine Breeding. Lesson plan prepared for use by county agents in swine production short courses with their producers. (AH a1-9)
Noland, P. R. 1962. Factors influencing productivity in crossbred pigs. Proc. 1962 Swine Study Day, July 17, 1962. Univ. of Ark. (AH a1-4)
Noland, P. R., Brown, C. J., and Gifford, Warren. 1963. The effect of inbreeding and other factors on productivity trials in the UARK Poland China line. (Abs.) So. Sect. Amer. Soc. Anim. Prod. Feb. 4-6, 1963. Memphis, Tenn. J. Animal Sci. 22:246. (AH a1-4)
Pani, N. S., Day, B. N., Tribble, L. F., and Lasley, J. F. 1963. Maternal influence in swine as reflected by differences in reciprocal crosses. Mo. Agr. Exp. Sta. Bul. (AH a1-6)
Pani, Narayan S. 1962. Importance of the breed of dam in the production of crossbred hogs. M.S. Thesis. Univ. of Mo. Libr. Columbia. (AH a1-6)
Rempel, W. E. 1962. Selection for crossbred performance in pigs. Minn. Farm & Home Sci. 19(3):8, 22. Spring. (AH a1-17)
Sumption, L. J. 1962. Herd building, the next stage of improvement. Inbred News. 12(1):3-7). Jan./Feb. (AH a1-7)
Sumption, L. J. 1963. Methods of maintaining gene pools. Proc. Canad. Soc. Anim. Prod. (AH a1-7)
Sumption, L. J. 1962. Selection of breeding stock. Proc. Nebr. Second Ann. SPF Swine Conf. (Mimeo.) pp. 23-28. (AH a1-7)
Sumption, L. J. 1962. What are records worth? Nebr. Agr. Exp. Sta. Anim. Husb. Dept. Swine Prog. Rept. 373:18-21. (AH a1-7)
Sumption, L. J. 1962. What are records worth? Inbred News. 12(2):8-11. Mar. (AH a1-7)
Whatley, Jr., J. A. 1962. Selection for crossbred performance. 47th Ann. Swine Short Course, Okla. City. (AH a1-8)
Whatley, Jr., J. A. 1962. Using performance records in swine selection. 11th Ann. Swine Short Course. Tex. Agr. Exp. Sta. MP-566:1-5. (AH a1-8)

Whatley, Jr., J. A. 1962. The value of crossbreeding in swine production. Fourth Ann. Swine Short Course, Okla. City. (AH a1-8)

Performance and Progeny Testing

Whatley, Jr., J. A. 1963. Performance and progeny tests for evaluating boars. Feeding and Breeding Tests. 37th Ann. Livestock Feeders Day Rept. Apr. 20, 1963. MP-70:36-41. (AH a1-8)

AREA NO. 17: SWINE--PHYSIOLOGY

Problem. Continued improvement in efficiency of swine production is dependent on new information regarding the physiology of growth and reproduction as well as environmental adaptation. Particularly in the field of swine fertility, considerable knowledge is needed regarding the development of artificial insemination, including semen and ova preservation and storage. Fertility problems in boars and sows seriously plague the efforts of the industry to produce prok at lowest cost. Development of new genetic aids for improvement of swine requires additional understanding of the physiological processes, particularly those involved in the growth and production of lean meat.

USDA PROGRAM

This is a continuing program conducted by physiologists on basic and applied studies on the physiology of reproduction, artificial insemination, effect of hormones on growth and development, and the physiology of growth and development particularly with respect to the mechanisms involved in fat deposition, muscular development, and inborn metabolic defects. Work in this area at Beltsville has been inactive due to vacancies. This program has been reactivated to develop basic knowledge about swine physiology. Cooperative studies on the physiology of reproduction are included in projects of the Regional Swine Breeding Laboratory at Missouri and Nebraska, with informal preliminary investigations in others when opportunities for them arise.

The Federal scientific effort on research in this area totals 2.4 man-years. Of this number, 0.1 is on physiology of reproduction, 2.0 on physiology of growth and development, and 0.3 on program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Selective fertilization and mating behavior. A comparison of natural mating at the Wisconsin Station with artificial insemination was conducted with sows of various breeds and ages. Fertility three to five days post-mating was used as the criterion of evaluation.

No significant difference in percent conception or percent fertility was noted between groups of sows mated naturally and those bred artificially on the second day of the first post-lactation estrus or on the second day of the second post-lactation estrus. Pooling the results from the naturally bred group with the group bred artificially indicated that conception rate was higher (100.0% vs. 85.4%) and percent fertility was higher

(89.8 vs. 46.3) when sows were bred on the second day of the second post-lactation estrus than when bred on the first day of the second post-lactation estrus.

Sows artificially inseminated on the first day of the first post-lactation estrus had a nonsignificantly higher percent fertility (69.3 vs. 50.5) and conception rate (90.0 vs. 84.2) than when inseminated on the first day of the second post-lactation estrus.

A greater percent of the Duroc sows had cystic follicles and the number of follicular cysts per sow was greater than Yorkshire sows. The frequency in Duroc-Yorkshire crossbreds was intermediate to the two purebred groups. (AH a1-10)

2. Factors influencing estrus and fertility. At the Missouri Station, intrauterine migration and embryonic death loss were observed in 119 crossbred gilts slaughtered at the 55th day of pregnancy. Intrauterine migration, determined by comparing the number of embryos in a uterine horn with the number of corpora lutea in the corresponding ovary, was observed in 41.2% of the gilts. The total ovulation rate of both ovaries did not seem related to the occurrence of intrauterine migration. However, an unequal ovulation rate between the ovaries of the same gilts was related to the occurrence of this phenomenon. Migration of the fertilized ova was from the left to the right uterine horn in 69% of the cases. The left ovaries averaged 1.32 more ova than the right. In spite of this unequal production of ova, the embryos were equally divided between the uterine horns at the 55th day of gestation. Where intrauterine migration was observed, litters averaged 1.24 more pigs; and where no intrauterine migration was observed, there were 1.73 fewer corpora lutea not represented by embryos. This suggests the possibility that intrauterine migration may be important in preventing embryonic death losses through equal distribution of embryos between the uterine horns. No evidence was found of a genetic basis for intrauterine migration of fertilized ova. Differences between sires and crossbred groups were not significant. (AH a1-6)

Four experiments at the Oklahoma Station involving 100 gilts and sows were conducted to test the hypothesis that the daily administration of orally active progestins would reduce early embryonic mortality by enhancing the environment within the uterus. Significant reduction in embryonic mortality occurred only when the embryonic mortality in the control animals approached 30% to 35%. There was an unusually low embryonic mortality in some control groups and a high degree of individual variation. Analysis of pooled data, wherein 33 pregnant animals given the 1 mg. of 17α-acetoxyprogesterone (17-AP) and 0.5 gamma diethylstilbestrol (DES) per pound of body weight daily were compared with 35 pregnant control animals, indicated a reduction in embryonic mortality (3.39 vs. 4.89 dead embryos) ($P < 0.17$). There was no reduction of embryonic mortality in the 12 pregnant animals given 6α-methyl-17α-acetoxyprogesterone (6-M-17-AP) compared with 14 pregnant control animals. The incidence of cystic ovaries at necropsy was 5 of 17 (29.4%) in the 6-M-17-AP treated groups, 4 of 45

(8.9%) in the 17-AP-DES treated groups and 1 of 38 (2.6%) in the control groups. Significant differences in endometrial alkaline and acid phosphatase activities did not occur between groups except when pregnant and nonpregnant animals were compared. (AH a1-8)

The effect of exogenous estrogens on corpus luteum maintenance in gilts was studied at the Wisconsin Station. Stilbestrol, estradiol-17-β, and estrone maintained functional corpora lutea in gilts when treatment was started by day 11 of the estrous cycle. Estrogen treatment resulted in a decrease ($P < .01$) in corpus luteum weight, and an increase ($P < .01$) in progesterone concentration without altering the total progesterone content of the corpora lutea. Estrone maintained significantly greater size of corpora than did estradiol-17-β. Five trials at the Wisconsin Station involving 193 sows and gilts indicate that 6-methyl-17-acetoxyprogesterone doses of 100 mg. or greater are required to inhibit estrus and ovulation in the gilt. One or more cystic follicles developed in 58% of the females after withdrawal of eight different hormone doses ranging from 50 to 400 mg. per head per day. Cystic follicles developed during treatment when a low dose of 60 mg. was fed and after treatment when the dose was 240 mg. Gilts fed 75 mg. developed fewer cystic follicles after hormone withdrawal if treatment was started during the follicular rather than the luteal phase of the estrous cycle. Sows maintained preovulatory size follicles for at least eight days after the withdrawal of 200 mg. or more, and gilts maintained preovulatory size follicles for eight days or more after the withdrawal of 400 mg. Sows also reached other dose response end points at a lower level than gilts. Increasing the duration of hormone feeding from 10 to 20 days resulted in more corpora lutea or follicles $\geq$ 6 mm. in diameter, fewer cystic follicles, and more preovulatory size follicles at eight days after hormone withdrawal. After withdrawal of 240 mg. dose, Yorkshire sows had developed cystic follicles, whereas Duroc sows had developed preovulatory follicles. Neither frequency of feeding the progestational hormone, the energy content, nor the fiber content of the ration affected the probability of ovulation or cystic follicle formation after hormone withdrawal. (AH a1-10)

A preliminary study of the influence of different levels of exogenous estrogen on ovarian function in the cycling gilt was initiated in the summer of 1962 at the Nebraska Station. Gilts were assigned at random to the following levels of estradiol-17-β as they exhibited their second estrus following the initiation of heat checks: (1) 50 μg/day, (2) 200 μg/day, (3) 800 μg/day, and (4) 1600 μg/day. Daily injections of estradiol were begun on day 11 of the estrous cycle and continued until slaughter on day 20 or day 31 following pretreatment estrus. Gilts were laparotomized and the corpora lutea marked with India ink on the day treatment was begun. Twenty-two gilts contributed data to this study. Estrous cycle length was not modified by daily injections of either 50 or 200 μg. of estradiol-17-β, but was significantly extended by the higher levels of estrogen. All of the gilts receiving 800 and 1600 μg. of estradiol had marked corpora lutea at slaughter on day 31. The gilts that returned to heat prior to slaughter had prolonged estrous cycles. The corpora lutea of the treated gilts were

somewhat lighter in weight than those from control gilts obtained on day 15 of the estrous cycle (285.0 and 256.1 mg. for the 800 and 1600 mg. treatments on day 20 and 285.7 and 285.2 mg. for the 800 and 1600 mg. treatments on day 31 vs. 430.5 mg. for control corpora lutea removed on day 15). The glands are being analyzed for progesterone content. More gilts are being added to this study at the present time. (AH a1-7)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Physiology of Reproduction

Day, B. N. 1962. The reproduction of swine. Reproduction in Farm Animals. Hafez, E. S. E., Ed. pp. 255-265. (AH a1-6)

First, N. L., Stratman, F. W., Rigor, E. M., and Casida, L. E. 1963. Factors affecting ovulation and follicular cyst formation in sows and gilts fed 6-methyl-17-acetoxyprogesterone. J. Animal Sci. 22:66-71. (AH a1-10)

Gardner, Mark L., First, N. L., and Casida, L. E. 1963. Effect of exogenous estrogens on corpus luteum maintenance in gilts. J. Animal Sci. 22:132-134. (AH a1-10)

Gibson, Earl Webb. 1962. Studies on the induction of superovulation in swine. M.S. Thesis. Univ. of Mo. Libr. Columbia. (AH a1-6)

Hafez, E. S. E., Sumption, L. J., and Jakway, J. S. 1962. The behavior of swine. Chapt. 12. The Behavior of Domestic Animals. Ed. Hafez. Bailliens, Tindall, & Cox, Ltd., London. (AH a1-7)

Herrick, J. B., and Self, H. L. 1962. Evaluation of fertility in the bull and boar. Iowa State Univ. Press. Ames. (AH a1-4)

Lasley, J. F., Day, B. N., and Mayer, D. T. 1963. Intra-uterine migration and embryonic death in swine. J. Animal Sci. 22:422-424. (AH a1-6)

Lasley, J. F. 1962. Factors affecting conception rate in swine. Factors Affecting the Performance of Livestock. Iowa Feed Conf. Sept. 14-15, 1962. AS-30:55-56. (AH a1-4)

Morrissette, M. C., McDonald, L. E., Whatley, Jr., J. A., and Morrison, R. D. 1963. Effects of progestins on embryonic mortality of swine. J. Vet. Res. 24:317-323. (AH a1-8)

Neill, Jimmy D. 1963. The effects of induced ovulation and hysterectomy on the maintenance of corpora lutea in swine. M.S. Thesis. Univ. of Mo. Libr. Columbia. (AH a1-6)

Self, H. L. 1962. Boar management. Iowa State Univ. Coop. Ext. Serv. AS-28. (AH a1-4)

Self, H. L. 1963. Some tips on better boar management. Pol. China World. March. 50(3):6-7, 13-14, 16. (AH a1-4)

Stratman, F. W. and Self, H. L. 1962. Fertility studies with naturally mated or artificially inseminated sows. J. Animal Sci. 21:647-650. (AH a1-4)

AREA NO. 18: SWINE --NUTRITION AND MANAGEMENT

Problem. The changing demands of the consumer to pork with a high proportion of lean are requiring major changes in the nutrition and management of swine. Furthermore, the use of materials other than lard has greatly reduced the demand for fat-type hogs. Along with the change in genetic makeup which must be made, basic facts concerning metabolic functions require investigation, and the basic nutritional factors which influence growth and carcass composition need to be identified and evaluated. These require information on quantitative and qualitative requirements at various growth stages and the changes in requirements to adjust for altered levels of other nutrients or modified environment. To meet the competition of other foods, including other meats, the nutrition and management of swine must constantly be aimed at improvement of feed and labor efficiency.

USDA PROGRAM

This is a continuing program conducted by biochemists, nutritionists, and animal husbandmen investigating basic and applied problems in swine production related to nutrition, metabolism, and management. Work is in progress at Beltsville, Maryland, and cooperatively with the Agricultural Engineering Division, the National Institutes of Health, and the Food and Drug Administration. These studies contribute to the establishment of nutrient and mineral requirements and the relation of different components of the diet to each other; to the development of more efficient and economical rations; to the relation of genetic differences to dietary requirements; and to the role swine may have as an experimental animal for the investigation of health and dietary problems in man.

The total Federal scientific effort in this area amounts to 7.9 professional man-years. Of this number, 1.0 is devoted to digestion and metabolism, 0.5 to concentrates, evaluation and utilization, 1.5 to forage evaluation and utilization, 3.0 to nutrient requirements, 1.1 to management practices and equipment, and 0.8 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

1. Effects of fiber variation on digestibility. A series of digestibility trials have been conducted at Beltsville to supplement the studies on forage and fiber in swine diets. The diets tested included a conventional diet, one in which corn and cob meal replaced corn, and a third containing 58% ground alfalfa hay. On a dry matter basis these contained 4.0%, 9.1%, and 17.8% of crude fiber, respectively. The diets were evaluated in a series of four digestion trials covering the weight range from 40 to 190 pounds to measure possible effects of age on utilization of feeds containing

widely divergent levels of fiber. Dry matter digestibility of the three diets in ascending order of fiber content was 85.7%, 73.8%, and 62.7% and N retention in the same order was 36.2%, 31.7%, and 22%. Age effect was negligible on dry matter digestibility ranging from 73.0% to 74.5% for the four trials but N retention dropped consistently from 38.9% in trial 1 to 21.0% in trial 4. A complete analysis of the data is in progress. (AH a2-4)

2. Effects of energy level on pigs with genetic differences in performance, type, and breed. An exploratory investigation was initiated at Beltsville last year to study the response of lines, selected either for maximum backfat or for minimum backfat (AH a1-12), to variations in nutritional treatment. The preliminary experiment was conducted with high-fat and low-fat Yorkshires in 1962-63 with pigs pair-fed within each line. One pig in each pair received an estimated metabolizable energy intake equal to two-thirds that of its full-fed mate. Balance trials provide more precise estimates of metabolizable energy content of the diets and measure responses of the different lines to this energy variation. Pigs are slaughtered at various specified ages up to one year and data are obtained on proportions of fat, lean, and bone at these ages.

Growth data from the preliminary experiment showed that pigs from the high-fat Yorkshire line gained 1.00 pound per day and required 3.55 pounds of feed per pound of gain. Comparable figures for the low-fat Yorkshires were 1.02 pound per day and 3.44 pounds of feed per pound of gain. Differences between energy levels were greater with high vs. low energy pigs gaining 1.10 pound and 0.93 pound daily at efficiencies of 3.59 pounds and 3.42 pounds of feed, respectively.

A line project (AH a3-18) has been submitted to expand this phase of digestion and metabolism investigations to include high- and low-fat lines from Duroc as well as Yorkshire swine.

B. Concentrates - Evaluation and Utilization

Cottonseed meal. Planned phases of investigation at Beltsville, Maryland, directed at improving the safety and use of cottonseed meal as a swine feed were completed. A final paper on correlation of nutritive indices by rat repletion and T. pyriformis W assay is being prepared. (AH a3-16)

C. Forage, Evaluation, and Utilization

Forage and fiber in swine diets. This experimental series at Beltsville is designed to define optimum levels of forage and/or fiber needed to produce a high level of reproductive performance with minimum costs for feed and labor. Gilts fed a pelleted diet containing 55 to 60% ground alfalfa hay (17-18% crude fiber) ad lib. as reported last year produced as well as gilts hand-fed a conventional corn diet (4% fiber) during gestation, and

were superior in reproductive performance to gilts receiving a ground ear corn diet (8% fiber) fed ad lib. in meal form. The satisfactory performance on the high level alfalfa hay diet was nullified by excessive wastage of the feed which could not be prevented under ad lib. feeding. The inferior performance on the ground ear corn diet was believed due to failure of this fiber level (8%) to restrict fatness of the bred gilts.

In order to minimize wastage of feed and more precisely evaluate fiber effects, gilts were allotted to three dietary treatments as they were bred (fall 1962). Planned daily ration for the respective groups was as follows: Group 1 gilt - five pounds basal gestation diet, group 2 gilt - five pounds basal plus 1.5 pounds ground corn cobs, group 3 gilt - five pounds basal plus 3.0 pounds ground corn cobs. Actual daily consumption per gilt was five pounds (basal) in group 1, six pounds (4.62 basal plus 1.38 cob) in group 2, and seven pounds (4.38 basal plus 2.62 cob) in group 3. Group 1 gilts averaged 8.7 pigs born, 7.4 pigs weaned (56 days) at an average weight of 32.1 pounds. Comparable figures for group 2 and group 3 gilts were 9.5, 8.3, and 30.7 pounds, and 9.5, 8.4, and 29.8 pounds.

These results suggest a beneficial effect on reproductive performance from bulk (or fiber) whether derived from hay or cob meal. However, for practical application some form of metering or restriction will be necessary to prevent excessive feed wastage. (AH a2-4)

D. Nutritional Requirements - Trace Mineral Requirements and Interrelationships

1. High zinc content in milk and colostrum of sows. Because of the marked variability in response of weanling pigs to low-zinc diets and the apparent importance of milk and colostrum as sources of zinc to suckling animals of some other species, Beltsville researchers have undertaken to determine the zinc content of sow's milk and colostrum. The first assays show 19.44 mg./kg. of zinc in 22 samples of sow colostrum and 8.25 mg./kg. in 15 samples of milk. Reduced to a solids-not-fat basis, the zinc content becomes 90.46 mg./kg. in colostrum and 69.53 mg./kg. in milk. Sow's milk and colostrum according to these figures contain substantially more zinc than milk and colostrum of cow, human, and ewe. Normal milk of these species has been reported to contain from 3 to 5 mg. zinc per kg. of milk which is much higher than the content of other trace minerals, while colostrum zinc is usually 3 to 5 times that of later milk. These figures are believed to be the first published values for swine milk and colostrum. Since all samples were obtained from sows which were on natural diets without supplemental zinc, later samples from supplemented sows may show higher concentrations of this element. (AH a3-12)

2. Zinc metabolism affected by dietary potassium. Beltsville workers have investigated the effects of imbalances of potassium (K) and of phosphorus (P) on zinc (Zn) metabolism in rats. Using a semisynthetic basal diet which contained 1.20% of calcium, variables included two levels

of Zn (18 ppm and 40 ppm), two levels of K (0.1% and 0.65%), and two levels of P (1.2% and 0.3%) in a 2x2x2 factorial design. The higher level of Zn increased rate of growth and efficiency of feed utilization, and produced higher serum phosphatase and higher Zn content in liver and hair with all four combinations of P and K tested. Zinc content of hair from rats on diets low in Zn averaged 129 ppm (range 120-143 ppm) while hair from rats receiving the higher Zn diets averaged 185 ppm (range 146-230 ppm). Levels of P tested had no apparent effect on any of the criteria measured. The higher level of K, like Zn (though to a lesser degree), improved feed utilization and increased growth rate and level of serum phosphatase, but high level K did not affect Zn storage in the liver and was associated with lowered Zn content of hair. (AH a3-12)

3. Factors which affect zinc deficiency in weanling pigs. Past attempts by Beltsville workers to study factors which might influence utilization and requirements of the weanling pig for dietary zinc have been largely nullified by failure to produce characteristic skin lesions of parakeratosis. Since these failures coincided with the addition of supplemental zinc to gestation and lactation diets, recent test pigs were produced by sows which received no supplemental zinc during gestation or lactation. To further enhance the zinc deficiency, dietary factors which might be expected to interfere with zinc absorption or metabolism were included in the treatments. The basal corn-soybean diet containing 1.2% calcium and 31 ppm of zinc was fed to lot 1 pigs (controls), while 1% of sodium phytate was added to lot 2 diet, and cadmium sulfate to supply either 42 ppm or 125 ppm of cadmium was added to diets for lots 3 and 4, respectively. In the control lot, three of four pigs showed some degree of parakeratosis and gained only .38 kilogram per day while all of the pigs in the phytate and low cadmium lots (2 and 3) and two of the four in the high cadmium lot showed marked parakeratosis. Their gains were 0.1, .05, and ,08 kilogram per day, respectively. Though not entirely consistent, excretion of uric acid tends to be lower in animals with higher levels of zinc in the liver and higher in active stages of parakeratosis. Sodium phytate appeared to decrease liver storage of zinc and to depress alkaline phosphatase activity in blood, gut, and kidney but without appreciably affecting liver phosphatase. Cadmium supplementation at both levels was associated with erratic and unpredictable levels of zinc in the liver and of enzymatic activity of tissues. (AH a3-12)

4. Sow supplement prevents baby pig anemia. A recent trial at Beltsville confirmed the dramatic breakthrough by University of Kentucky researchers in the field of baby pig anemia. Blood tests on 36 litters of pigs demonstrated that a new iron compound when fed to a sow from four or five days prepartum through lactation will maintain adequate levels of hemoglobin in the blood of her suckling pigs. While hemoglobin increase is not quite as pronounced during the baby pig's first week of life as the increase due to injectable iron-dextran, it continues a steady buildup until it reaches the same level at from three to four weeks of age. (AH a3-12)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Digestion and Metabolism

Hoefer, J. A., Pearson, A. M., Stevenson, J. W., and Luecke, R. W. 1963. Effect of fibrous feedstuffs fed during the finishing period on gain, feed efficiency and carcass characteristics of swine. Quarterly Bulletin, Mich. Agr. Exp. Sta. Vol. 45, No. 3, pp. 480-490. (AH a3-17(c))

Morgan, D. P., and Davey, R. J. 1963. Adjustable equipment for separate collection of excreta from barrows. (Abs.) Va. Jour. of Sci. Vol. 14, No. 4. (AH a3-12)

Nutritional Requirements

Davey, R. J., and Stevenson, J. W. 1963. Pantothenic acid requirement of swine for reproduction. J. Animal Sci. 22:9-13. (AH a3-11)

Scarborough, V. C., and Earle, I. P. 1963. Composition of swine colostrum and milk: Major constituents and zinc. (Abs.) Va. Jour. of Sci. Vol. 14, No. 4. (AH a3-12)

Management Practices, Equipment, and Facilities

Agrisearch Note: Mobile air conditioner for sows. Agr. Res. Mar. 1963, p. 15. (AH a2-3)

AREA NO. 19: FUR ANIMAL HUSBANDRY

Problem. Fur animal investigations are needed to obtain fundamental information on methods of increasing the productivity of ranch-raised fur animals, including rabbits. Controlled research is needed on the development of superior lines, or possibly new breeds, for producing higher quality fur and better rabbit meat. The genetics of mutations of mink and foxes and the inheritance of factors for quality of fur and of meat in rabbits require continuous study. Feeding investigations are needed to determine nutritive requirement of various species and the most economical sources of feed to meet their requirements. Of special need is the finding of satisfactory substitutes for expensive raw meat. Low cost byproducts of the meat and fishing industries must be under constant study to develop practical diets. Successful husbandry of these animals requires extensive study of the peculiar characteristics of reproduction and their relation to productivity.

USDA PROGRAM

This is a continuing program and involves (1) genetic investigations of traits for use in improvement of rabbits, minks, martens, and foxes; (2) research on the reproductive performance of mink, including the effects of hormones and the process of lactation; (3) estimates of genetic parameters and maternal effects concerning economic traits in the production of fryer rabbits; (4) studies with regard to the priming process in fur bearing animals through investigations of the mechanisms involved in the growth of hair follicles; (5) research on the basic nutrient requirements and nutrient utilization by mink and the development of diets based on fish, meat and their byproducts for mink, fox, and marten; and (6) the relationship of nutrient factors and physical characteristics of the diet to rabbit production, including the study of various proteins.

The work is in progress at Beltsville, Maryland; Fontana, California; Ithaca, New York; and Petersburg, Alaska. Cooperation is maintained with Swarthmore College and State Experiment Stations of Alaska, California, New York, and Wisconsin. Close cooperation is maintained with the National Board of Fur Farm Organizations.

The Federal scientific effort devoted to the research in this area totals 5.5 professional man-years. Of this number 0.7 are devoted to fur animal breeding, 0.9 to fur animal physiology, 3.7 to fur animal nutrition and management, and 0.2 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Fur Animal Breeding

1. Genetic investigations of traits for use in breeding, selection, and improvement of meat rabbits. A survey in cooperation with the University of California at Davis was made of the reproductive records of the U. S. Rabbit Experiment Station, Fontana, California, to determine the effect of age of dam on mortality due to pneumonia, enteritis, and pneumonia plus enteritis. Age of dam was indicated by the number of litters a doe produced. A total of 19,854 young rabbits was surveyed, ranging from 4,310 in first litters to 5 in a 26th litter. Results indicated that enteritis mortality increases with the age of the dam up to, and including, her 10th litter, and then decreases from the 11th litter on. This apparent effect also showed up in mortality due to pneumonia, but not mortality due to enteritis and pneumonia combined. Percent mortality due to enteritis and pneumonia combined showed a linear increase with increasing age of the doe. It might be postulated that the decrease in mortality due to enteritis or pneumonia in later litters is due to a process of selection, because does with high mortality in early litters were culled from the herd.

Additional work was done in cooperation with the University of California at Davis on doe age and seasonal effects on weaning traits of rabbits at Fontana, California. This work grew out of a genetic variance component analysis completed earlier and reported last year. The results indicate that the months of March and April appear to produce maximum weaning weights (3.92 pounds); while the months of July through October produce lowest weaning weights for a doe's first litters (3.57 pounds), and September through October produce lowest weaning weights for later litters (3.78 pounds). Individual weaning weights of a doe's first litter are usually poorer (3.72 pounds) than her later litters (3.95 pounds). (AH f1-1)

2. Genetics of mink with emphasis on mutant traits and pelt quality. Experiments designed in the Departments of Meat and Animal Science, and Genetics, of the University of Wisconsin, in cooperation with the Sheep and Fur Animal Research Branch, to study all combinations of mutant genes affecting coat color are continuing in a herd of approximately 250 female mink. Mutant genes affecting characters other than color phase are becoming increasingly more important and are incorporated into the breeding herd as available. Maximum effort was directed toward the immunogenetics of the mink during the past one and one-half years, with some attention also to the blood picture in the marten and ferret.

Three blood type systems have been found and their mode of inheritance worked out in the herd at the Wisconsin Fur Animal Research Laboratory and on two of the larger commercial ranches in the State. Blood types A, B, and C in the A system result from triple alleles, and reagents have been developed which allows for observing a 1:1 relation between genotype and

phenotype. This system is of particular interest to (1) commercial breeders since it is clearly involved in neonatal deaths which is the largest single source of losses on mink ranches, and (2) to biologists because erythrocyte mosaicism within this system has been demonstrated in the mink which is the first case in a normally litter-bearing species. The E system appears to segregate independently of the A system. Data bearing on the relation of the D system to the other two have not yet been evaluated. (AH f1-2)

B. Fur Animal Physiology

1. Delayed implantation in the mink. The mink is unique among animals exhibiting delay of implantation, in that both breeding and fertilization may occur during the delay period. As might be expected, considerable variation in structure of the female reproductive tract is found during the delay period. Contrary to previous reports, it was found in studies at Swarthmore, Pennsylvania, that the corpora lutea luteinize but the cells do not hypertrophy until implantation. The variation in structure of the reproductive tract may be correlated with follicular or luteal ascendancy. However, a regular cycle during delay cannot be discerned.

The reported differences observed in the uterus indicate that the environment of the blastocysts varies considerably during the delay period. The ability of the mink blastocysts to withstand altered environmental conditions has been previously demonstrated in vitro. This would appear to be another instance where the requirements for continued existence of the blastocyst are less restrictive than those for continued development.

The variation in condition of the reproductive tract during the delay period makes the administration of exogenous hormones of doubtful usefulness in interpreting the hormonal basis of delayed implantation in this species. This variation may help to explain the negative results obtained by others with progesterone and with estrogen plus progesterone in attempting to induce implantation in the intact mink. (AH f2-1)

2. Mating systems for the marten. Reproduction of marten has been inconsistent and sporadic in attempts by public agencies or private industry to propagate these animals in captivity. The herd at Petersburg, Alaska, is located in an area where wild marten are quite numerous, and diets have been perfected which insure good health, yet re-production has varied with from none to one-half the mature female breeders producing young.

During the 1962 breeding season, which started July 3 and terminated September 12, only 9 matings were observed with 5 females though several pairs were left together unobserved for 24 hour periods. At whelping in April the actions of two bred females indicated the probability of their whelping, yet no young were born. This reduced breeding activity and lack of any reproduction has only occurred once before at this station. In an attempt to instill more activity during the 1963 breeding season, the amount of feed offered the marten during May and the forepart of June was reduced by 35 percent.

Three wild-caught marten, one female and two males, were added to the station herd in January. (AH f1-4)

3. Effects of temperature on mortality of rabbits. The effects of average maximum and minimum temperatures on mortality due to enteritis, pneumonia, enteritis and pneumonia, and "other" causes were studied at Fontana, California, in cooperation with the University of California at Davis from records taken for the years 1955-1959. Regressions were calcuated by years between the average maximum and minimum temperatures and the various causes of death. The results indicate that temperature is inversely related to incidence of enteritis, and is directly related to pneumonia and to both diseases combined. No close relationship to temperature was found with "other" diseases. (AH f1-1)

4. Effect of breeding does at various intervals following kindling on reproductive performance. This experiment at Fontana, California, designed to evaluate the effect of breeding does at various intervals following kindling, with regard to the effect on the development of the young and reproductive life of the dam, was completed. The data have been submitted to Biometrical Services, Beltsville, for analysis, but a brief summary of the results follows. A total of 54 does were subjected to test; 25 with a breeding interval of 31-32 days; 11 with a breeding interval of 38-39 days following parturition; 10 with a breeding interval of 45-46 days; 8 with a breeding interval of 52-53 days. The data appear to indicate that does on the fastest breeding schedule had a shorter reproductive life, in that only 4 out of 25 raised as many as 4 consecutive litters, while 7 out of 8 does raised 4 consecutive litters under the slowest breeding schedule. The number of young born alive and dead did not seem to be materially affected by the breeding schedule; while individual weaning weights and number weaned per litter were apparently increased on the more rapid breeding schedule. An analysis of the results will be required to determine any significant effects. Since there is a continued tendency in commercial rabbit production to shorten the breeding interval and gain the advantage of greater total fryer production, further studies along this line were determined advisable. Therefore, a new study is being started to further evaluate the effects of breeding does at short intervals following parturition on the reproductive life of the does, growth of the young, the incidence of enteritis, and total mortality. Currently, experiments are under way involving breeding intervals of 10-12 days and 24-25 days following parturition. (AH f1-6)

5. Skin samples for estimating fur quality. The mink rancher has expressed a need for a practical method to evaluate fur quality on which he can base his selection of animals for density of fur. This method must be a quick method and simple to use. The present histological techniques now employed in the laboratory are too time-consuming. After several trials, a light-weight, trigger-type hand instrument was developed at Beltsville, Maryland, for the taking of biopsy samples. This has been used effectively on both rats and mink. Current work now underway is pointed toward the

development of techniques to provide fast and simple processing of the biopsy material for the determination of the number of hair follicle groups in a given area. (AH f4-3)

C. Fur Animal Nutrition and Management

1. Development of diets for fur animals based on sea fish and sea mammals and their products. Studies at Petersburg, Alaska, have shown that a number of antioxidants have adequately protected young, growing mink receiving rations containing ingredients high in unsaturated fatty acids from steatitis, but some of these products have proven detrimental to reproduction or have physical properties which render them difficult to use. Vitamin E will also prevent this malady. However, exact requirements to equal the protection afforded by a proven antioxidant are not known and the relationship of these two additives is not very well understood.

Two new antioxidants, UOP 88 and UOP 288, which may have some reactivating influence on vitamin E lost during oxidation, were compared with the antioxidant BHT and two levels of vitamin E in rations fed six equal groups of female mink from February until weaning in June. Fifty young animals from each group were kept on their respective diets until pelting in December. Reproduction on the diets containing the UOP 88, UOP 288 and low level of 6 I.U. per pound of vitamin E was below normal. Rations containing BHT and 12 I. U. per pound of vitamin E were adequate from a production standpoint and all three of the antioxidants were effective in preventing steatitis in growing mink. A very low incidence of steatitis among the animals receiving 12 I. U. of vitamin E per pound of feed indicated that this amount may be very near the minimum requirement of that vitamin for full protection. Fur quality was superior in animals adequately protected from steatitis.

At Petersburg, Alaska, the addition of the antioxidant BHT (Butylated hydroxy toluene) to the diet of the station's small fox herd of 10 females during 1960 resulted in better production and fur quality in 1961 with 8 out of 10 females producing a total of 33 pups whose pelts brought higher prices than the previous year. The same management and diet in 1962 resulted in 7 out of 10 females producing 49 pups, and pelts sold the following winter averaged nearly 25 percent more in value than the 1961 pelts. No doubt, part of this increased value was due to greater interest in fox furs by the fur trade but it also indicates that the antioxidant was a beneficial addition to the diet. These results were further supported by good reproduction in the fox herd in 1963.

There are over three million pounds of high protein meat products available and going to waste on the Pribilof Islands in Alaska in the form of fur seal carcasses, a byproduct of the U. S. Fish and Wildlife Service fur seal operation. A preliminary feeding trial was carried on at Petersburg, Alaska, with two groups of 50 young mink from September 26 to December 6 to determine any possible advantage in feeding this product to mink during

the furring-out season. A ration containing 25 percent fur seal meat was compared to a similar diet in which 30 percent chum salmon heads replaced the meat.

Health was satisfactory in both groups, though three inferior cotton pelts developed on the all-fish ration and one in the lot receiving the meat. Weight increases were very similar but the animals receiving the fish ration consumed slightly more feed. Fur Quality was significantly better in the meat fed group. Female pelts from each lot sold for comparable prices but male pelts from animals receiving the meat brought an average nearly $2.00 more than those which had received the high fish diet. (AH f3-1)

2. Relationship of nutrient factors and physical characteristics in diet to rabbit production. The data from experiments at Fontana, California, investigating the effects of continuous and temporary feeding of oxytetracycline and chlortetracycline on weight gains, incidence of enteritis, and the control of diseases in rabbits, have been compiled and analyzed. The experiment utilized three groups of animals involving a total of 37 does and 1,002 young, being fed as follows: Group 1, control ration supplied ad libitum throughout each pregnancy and lactation until the young were weaned; Group 2, control ration supplemented with 100 grams chlortetracycline, 50 grams oxytetracycline per ton continuously fed ad libitum throughout each pregnancy and lactation until the young were weaned; Group 3, control ration supplied ad libitum throughout pregnancy and lactation until the young were 35 days of age, control ration supplemented with 100 grams chlortetracycline and 50 grams oxytetracycline per ton supplied ad libitum for 10 days until the young were 45 days of age, and the control ration supplied ad libitum again until weaning. Supplementing the ration had no significant effect on growth, as measured by weaning weight of the young, except in a doe's first litter. Antibiotic supplementation did significantly lower the incidence of enteritis and also the mortality due to enteritis. Continuous supplementation restricted the incidence of enteritis to the largest litters. It had no apparent effect on enteritic rabbits once they had contracted enteritis. No evidence was obtained which would indicate a cumulative effect, nor that antibiotic supplementation in a doe's early litters affected the susceptibility of later litters to enteritis. Of all treatments, continuous supplementation of antibiotics was most favorable for total production in terms of number and total weight of rabbits weaned per doe.

Analyses were completed at Fontana, California, in cooperation with Commercial Solvents, Inc., on the effects of zinc bacitracin on the incidence of enteritis and growth of young rabbits. Forty New Zealand White does were placed on experiment and randomly divided into 4 lots of 10 does each. The does remained on test, where possible, through three successive litters. Four rations were utilized, one for each total of 10 does. Two rations served as controls, and two rations contained zinc bacitracin at calculated levels of 50 grams per ton.

A total of 722 young were reared on experiment and the results were evaluated on the basis of individual weaned weights, nest box mortality, enteritis mortality, and feed conversion as determined by the amount of feed required to produce one pound of weight at weaning. Since nest box mortality is that which occurs between 1-21 days of age, and is usually due to exposure, hunger, pneumonia and injuries, only young over three weeks of age were considered in the analysis of enteritis mortality. The results indicated that the addition of zinc bacitracin to rabbit rations containing 18 percent to 22 percent crude protein reduced enteritis mortality in animals three to eight weeks of age in amounts approaching significance at the 5 percent level of probability. The addition of zinc bacitracin had no significant effect on nest box mortality, feed conversion, or growth of the young as indicated by weaning weights.

Investigations at Fontana, California, in cooperation with Merck and Company, Inc., on the effect of a penicillin-streptomycin mixture (Pro-Strep) in rabbit rations on the growth and incidence of enteritis in young rabbits, have been completed. In this experiment, 3 rations were fed, a control, a control plus 20 grams Pro-Strep per ton of feed, and a control plus 100 grams of Pro-Strep per ton of feed. The test involved the feeding of 539 young rabbits from birth to weaning at 8 weeks of age. Results suggest that Pro-Strep at the 20 gram per ton level produced a slight increase in weaning weight, but no increase at the 100 gram per ton level. Supplementing with Pro-Strep produced no appreciable effect on nest box mortality. With regard to enteritis mortality, there was no appreciable difference between young receiving the control diet and those receiving the control diet supplemented with 20 grams of Pro-Strep. There was, however, a large difference in enteritis mortality among rabbits receiving the control diet or control supplemented with 20 grams of Pro-Strep, and those receiving the control diet supplemented with 100 grams of Pro-Strep. Mortality in the latter group was between three and four times that of the low level supplementation and control groups. This especially high mortality was consistent and uniform throughout all litters, and suggests that this high level of antibiotic supplementation was having a marked adverse effect on the intestinal flora and digestive processes. (AH f3-2)

3. Studies of protein in rabbit feeds. An experiment at Fontana, California, to study the tolerance of rabbits for cottonseed meal at levels of 0, 4, 7, 10 and 13 percent in the diet, was completed. A split-plot randomized block design was utilized. Data were analyzed by Biometrical Services, ARS, Beltsville, Maryland. Thirty mature does and five diets were incorporated into six blocks. Where sisters were available, they were assigned to different blocks and received different diets. Rations were assigned at random to the five does in each block and each doe received the same ration throughout successive litters. Due to reproductive failures and mortality among does, replacements were necessary and a total of 46 does were used: 7 on diet 1, 10 on diet 2, 10 on diet 3, 8 on diet 4, 11 on diet 5. A total of 124 litters was produced, 25 on diet 1, 25 on diet 2, 24 on diet 3, 24 on diet 4, 26 on diet 5. Results were evaluated

on the basis of average individual weaning weight, total litter weaning weight, total mortality, enteritis mortality, feed conversion and number weaned. The analyses of variance were calculated both adjusted and unadjusted for covariance of rabbit feeding days. No significant difference between diets was indicated for any of the traits indicated. Further, there were no significant linear or quadratic responses to increased levels of cottonseed meal for any of the traits. This was somewhat surprising in view of the significant linear and quadratic responses of unadjusted total litter weight in the previous study. The unadjusted total litter weight was related to the number weaned, although the analysis showed no significant difference between rations, the means for total litter weight, average litter weight; and mortality suggested an adverse effect of increased levels of cottonseed meal. To determine whether these apparent differences were real will require a more extensive study with refinements in data collection and analytical procedures. (AH f3-4)

4. Investigations of the basic nutrient requirements and nutrient utilization by mink. At Ithaca, New York, ten young mink were placed on a niacin deficient diet to further test if true niacin deficient symptoms had been obtained in the 1961 experiment. Additional tests were needed to determine if black tongue would occur as in other species. Niacin deficiency symptoms obtained in the 1961 study were confirmed. No black tongues were observed in either year.

A study was initiated at Ithaca, New York, to determine the requirement of the growing mink for pantothenic acid. Five lots of 20 males each were fed on a purified diet containing pantothenic acid at levels of 0, 4, 8, 12, and 15 mgs. per kgm. of diet. Ten female kits were allotted to the deficient diet to further observe deficiency symptoms. Typical pantothenic acid deficiency symptoms were severe emaciation, enlarged adrenal glands, small livers, stomach ulceration with hemorrhages, porphyrin stained bile, and some but variable muscular incordination after the 35th day. The tabulation of results suggests that the lowest level of pantothenic acid fed (4 mg. per kgm.) produced growth similar to, though statistically inferior, to the control and higher pantothenic acid levels.

Sixty mink kits equally divided as to sex were allotted to six experimental groups with 10 animals per group and started on an experiment at Ithaca, New York, to determine the degree to which growing mink utilize Beta carotene as a source of vitamin A activity. All animals were fed a purified diet with pure vitamin A or carotene source administered orally once weekly when called for. The animals made reasonable growth but because of their initial weights did not show significantly different growth patterns. The group receiving vitamin A did have a greater average final weight, however, and a higher plasma and total liver storage. There is essentially no difference between the deficient groups and the groups receiving carotene. This suggests that carotene, if used at all, was used inefficiently. (AH f3-5)

5. The development of practical diets and feeding practices for minks. An experiment was conducted at Ithaca, New York, with 100 growing mink kits (50 males, 50 females) to test three different cereal mixtures for desirability, economy and practability in the feeding of growing mink. Lot 1 (20 males and 20 females) received a cereal similar to the commercial "Supersheen." Lot 2 (15 males and 15 females) received cooked wheat as the cereal, and Lot 3 (15 males and 15 females) received a cereal formulation made up at the University of Wisconsin. All diets were alike except for the different cereals used. Every 19.50 pounds of cereal was supplemented with 1/2 pound of ground limestone.

The group receiving the ground cooked wheat (2) registered the greatest gains in body weight. They also showed the greatest body length although this difference was not statistically significant. Fur studies indicated that the cooked wheat group had the highest percentage of pelts graded good (93.10%) followed by Lot 3 (88.89%), and Lot 1 was last (78.95%). The ground wheat was also the most economically fed group since the wheat cost $3.65 per 100 pounds as compared to $7.50 for the commercial cereal.

These studies, when combined with those conducted earlier, demonstrate quite clearly that a diet consisting of muscle meat, viscera and cooked wheat with a small amount of an antibiotic and ground limestone, when fed to growing mink, will give as good live weight gains, gains in body length, good general health and good desirable pelts, as either the Wisconsin or the revised commercial cereals at a savings of more than 50 percent of the cost of the cereal.

A study was designed at Ithaca, New York, to determine if reproduction of rats was detrimentally effected when gullets or weasands from slaughtered veal calves were included to the extent of 50 percent in the diet fed. This study was preliminary to the initiation of similar studies with mink to determine the probable cause or causes of the exceedingly poor production of young which certain ranchers in New York and Pennsylvania had recently suffered. Four lots were set up with 10 animals per lot. Diets fed were: Lot 1, commercial dog food; Lot 2, control plus 0.30 percent dried thyroid-parathyroid; Lot 3, control plus 1.5 percent dried thyroid-parathyroid; and Lot 4, control plus 1.5 percent gullet trimmings minus the thyroid-parathyroid. Reproduction and lactation were satisfactory only in Lot 4. It was concluded that the feeding of dried thyroid and parathyroid glands at levels of 0.3 percent and 1.5 percent of the ration, to female rats, had an adverse effect upon reproduction and lactation performance causing almost complete loss of the litters within 14 days of birth. The glandular activity of the harmful diets corresponds to the addition of 10 percent and 50 percent of "gullet trimmings" to a mink diet in which the cereal level was 20 percent. From the above evidence on rats, plus the circumstantial field evidence on mink, it was recommended that ranchers do not feed this material to mink during the reproduction season until more is known of its effects.

An experiment was conducted at Ithaca, New York, to study various practical diets on reproduction of mink. Experimental groups consisted of a control group of 14 females, a group of 22 females fed trawler chubs, a group of 19 females fed a diet without liver, two groups of 16 females fed gullets, and a group of 9 females fed seal meat. Satisfactory production of young alive at 14 days was obtained only with the control and the seal meat diet with 4.00 and 3.56 young per female, respectively. Exclusion of liver from the diet resulted in a marked reduction in young with 2.37 kits per female alive at 14 days. The trawler chub diet also gave unsatisfactory reproduction with 1.14 kits per female alive at 14 days. Poorest reproduction was shown by the groups on the gullet diets with 0.31 and 0.69 young per female alive at 14 days after birth.

A study was conducted at Ithaca, New York, with 120 mink kits (60 males and 60 females) to determine if trawler chubs from the Great Lakes could be used as a practical and economical diet ingredient for growth of young mink. Five lots of animals were included in this study with 20 males and 20 females in the control group (Lot 1) and 10 of each sex in each of the other groups. Diets fed for the different lots were equal parts of chicken waste, lungs, tripe and muscle meat, plus liver 5 percent and a cereal mixture 20 percent (Lot 1), whole chubs 30 percent replacing an equal amount of the viscera and muscle meat of Lot 1 (2); gutted chubs replaced the whole chubs of Lot 2 (3); chub guts replacing whole chubs of Lot 2(4); and canned chubs replacing 30 percent of the whole chubs of Lot 4, and 3 percent of the viscera of Lot 1 (Lot 5). General health, food consumption, feed costs and fur quality were fairly comparable in all groups. (AH f3-6)

6. Influence of low potassium diets on hair growth pattern in the rat. Studies to determine the effects of low potassium diets on the coat of the mink have been initiated at Ithaca, New York, to learn (1) whether the requirements for potassium may vary under different conditions, and (2) to ascertain what these requirements may be. The effects of dietary mineral imbalances with weanling rats at Beltsville, Maryland, showed that reduction of potassium to 0.1 percent of the diet will produce an unusual hair growth pattern of a type not previously observed. The first indication of a difference in the hair coat was noted one month after the start of the experiment, at the time the animals were 8 weeks of age. The normal rhythms of shedding and subsequent hair growth in these animals were out of phase owing either to a more rapid molting in the zone of expected active hair growth or to the dormancy of some of the follicles in this zone since they failed to regenerate hairs. Body growth was somewhat retarded. (AH f4-3)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Fur Animal Breeding

Casady, R. B., and Sittmann, D. B. 1962. Sex differences in rabbit mortality due to enteritis. Small Stock, 46(10), p. 6 (AH f1-1).

Casady, R. B., Rollins, W. C., and Sittmann, D. B. 1962. Effects of season and age of dam on individual weaning weights, number weaned and total litter weight of hutch-raised domestic rabbits. Small Stock, 46(11), p. 7, 23, and other rabbit journals (AH f1-1).

Rapacz, J., and Shackelford, R. M. 1962. Immunogenetics of the domestic mink: Blood group factors A, B_1 and B_2. Nature, 196, p. 1340-1341 (AH f1-2).

Rapacz, J., and Shackelford, R. M. 1962. Immunogenetic studies in the domestic mink. Immunogenetics Ltr., 3, p. 55-62 (AH f1-2).

Rapacz, J., and Shackelford, R. M. 1963. Inheritance of blood factors in the A system of the domestic mink. Immunogenetics Ltr., 3(2) (AH f1-2).

Shackelford, R. M. 1962. Genetic Section of "Ask the experts", American Fur Breeder, monthly column (AH f1-2).

Shackelford, R. M. 1963. Types of mink (Section I). Blue Book of Fur Farming (AH f1-2).

Shackelford, R. M., and Hartsough, G. R. 1963. Breeding (Section IV). Blue Book of Fur Farming (AH f1-2).

Fur Animal Physiology

Cochrane, R. L., and Shackelford, R. M. 1962. Effects of exogenous estrogen alone and in combination with progesterone on pregnancy in the intact mink. J. Endocrinology 25, p. 101-106 (AH f2-1).

Dolnick, E. H., and Sanne, S. 1962. Hudens byggnad och harens tillvaxt hos mink. Vara palsdjur, p. 259-261. (October) (AH f4-3)

Fur Animal Nutrition and Management

Bassett, C. F., and Warner, R. G. 1962. Do antibiotics help in producing larger and healthier mink? National Fur News, 34(11), p. 10, 39. (AH f3-6)

Casady, R. B. 1962. Antibiotics and drugs in the rabbit ration. National Rabbit Raiser, 30(2), p. 8, Part II 30(3), p. 8 (AH f3-2).

Casady, R. B. and Hagen, Jr., K. W. 1963. The value of zinc bacitracin in rabbit rations. Small Stock, 47(1), p. 7, and other rabbit journals (AH f3-2).

Leekley, J. R., Cabell, C. A. and Damon, Jr., R. A. 1962. Antioxidants and other additives for improving Alaska fish waste for mink feed. J. Anim. Sci., 21(4), p. 762-765 (AH f3-1).

Travis, H. F., Sperling, G., Bassett, C. F., and Warner, R. G. 1963. Some effects of feeding gullet trimmings to rats during the reproductive cycle. Fur of Canada, 28(3), p.5, and other trade journals (AH f3-6).

AREA NO. 20: ANIMAL PERFORMANCE AND MANAGEMENT RECORDS

Problem. Livestock and poultry improvement cannot be accomplished effectively without adequate records of performance and management. Furthermore, records which have widespread utility must be produced through carefully coordinated programs in order that uniformity may be obtained in measurements and analytical procedures. Continual revision of record procurement and evaluation techniques in accordance with current research findings requires integration of program operations and research. Only in this way can there be a continual chain of discovery, application and field testing.

USDA PROGRAM

This is a continuing long-term program of performance testing dairy cattle and poultry, including the evaluation of the genetic merit of dairy cows, sires and herds, chickens for egg or meat production, and turkeys. Also included in the program is the control of hatchery disseminated poultry diseases. The work on dairy cattle performance testing is cooperative with 50 States and Puerto Rico and the Records and Breeding Committees of the American Dairy Science Association. Cooperation is also carried out with the National Association of Artificial Breeders and the various dairy cattle breed registry organizations. The poultry work is cooperative with Official State Agencies in 47 States and with the supervisors of 34 random sample tests in the United States and Canada.

The Federal scientific effort devoted to the programs in this area totals 6.5 professional man-years. Of this number, dairy cattle work accounts for 3.3, 3.0 devoted to performance testing and 0.3 to program leadership, and poultry work accounts for 3.2, 3.0 devoted to performance testing and 0.2 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Dairy Cattle

1. Sire evaluation program. Automatic data process (ADP) facilities were used to provide sire evaluations in July and January. Evaluations were based on contemporary herdmate comparisons and included 24,941 sires having either five or more production-tested progeny or a 50 percent or more increase in number of progeny since the last summary. This method of sire evaluation was used because it minimizes the effect of variations in production attributed to herd and year and season of calving.

Both natural service and AI sires were summarized on the basis of the daughters' average, minus the average of the adjusted herdmates. For each individual lactation of a sire's daughter, the herdmates' average was adjusted as follows:

Adj. Daughter Av. + Breed Season Av. + $\frac{\text{No. Herdmates}}{\text{No. Herdmates} + 1}$ X (Herdmate Av. - Breed Season Av.)

Since the progeny of AI sires normally represent different herds and environments, the daughters' averages of AI sires were further adjusted for herd-level effects as follows: Adj. Daughter Av. = Daughter Av. - 0.9 (Adj. Herdmate Av. - Breed Av.).

AI sires vary widely in number of production tested progeny. In order to adjust for this between sire effect and make it possible to more accurately rank sires according to their estimated transmitting ability, predicted averages were derived for AI sires as follows: Predicted Av. = Breed Av. + $\frac{\text{No. Daus.}}{\text{No. Daus.} + 12}$ (Adj. Daughter Av. - Breed Av.)

From the master tape files, which include 7,188,349 lactation records, a total of 3,333 AI and 21,608 non-AI sires representing 633,106 progeny were evaluated. The 50,494 individual sire reports resulting from these evaluations were provided to the cooperating States along with bound copies of the summaries.

When the progeny of all AI sires were compared with their herdmates, 48 percent maintained or increased milk yield and 57 percent maintained or increased fat yield. The corresponding values for natural service sires were 46 and 48 percent, respectively. The production averages of progeny of all AI sires were 11,139 pounds of milk and 448 pounds of fat. The corresponding values for natural service sires were 11,069 and 441 pounds. It was apparent from these summaries that AI sires were selected more on the basis of percentage of fat or fat yield than for milk yield. (AH i4-1)

2. Dairy recordkeeping programs. The 1,441 dairy herd improvement associations employing 2,216 supervisors provided the organizational machinery for operating the program in the cooperating States. Participation in the dairy recordkeeping plans for the National Cooperative Dairy Herd Improvement and Sire Evaluation Program was as follows:

Plans	Herds	Cows
Standard DHIA	41,937	2,006,534
Owner-Sampler	25,376	726,478
Weigh-a-Day-a-Month	1,500	50,492
Total	68,813	2,783,504

A total of 1,211,407 lactation records was reported to the Dairy Cattle Branch for use in sire evaluation and research. The 10 State or Regional Computing Centers continued to expand in the use of ADP facilities and processed 66 and 50 percent of the Standard DHIA and Owner-Sampler herds, respectively. The transfer of herds from Herd Improvement Registry (HIR)

to Dairy Herd Improvement Registry (DHIR) continued and now includes 3,100 herds.

The Artificial Insemination Program (AI), through which the superior sires developed and recognized in DHIA herds are utilized, continued to expand. In all, 7,748,687 cows were bred artificially, representing approximately 40 percent of the nation's dairy cows of breeding age. On January 1, 1963, there were 2,158 dairy and 401 beef bulls in 51 AI studs. These sires inseminated an average of 3,155 cows during 1962. The progeny of 677 AI sires evaluated on January 1963 produced 11,139 pounds of milk and 488 pounds of fat while their herdmates yielded 11,187 pounds of milk and 447 pounds of fat. (AH i4-2)

3. DHIA record analysis. An analysis of DHIA yearly herd records from 32,794 Standard DHIA herds and representing 1,531,826 cow-years showed that in 1961-62 the average production of cows was 11,032 pounds of milk and 426 pounds of fat. This was the highest yearly average to date by DHIA cows and represents a production advantage over non-DHIA cows of approximately 4,100 pounds of milk. Dairymen in the Standard DHIA Plan fed an average of 3,600 pounds of concentrates, 8,200 pounds of succulent forage, and 4,000 pounds of dry forage per cow-year and allowed cows on pasture 165 days. These feeding levels were in each instance higher than in the previous year and reflect the importance of sound feeding and management on productivity.

Extreme variations in herd levels were evident. There were 137 herds representing 6,720 cows which produced less than 5,500 pounds of milk per year while 8,963 herds having 336,368 cows averaged 11,500 pounds of milk or more and 183 herds with 6,763 cows produced over 15,500 pounds of milk. (AH i4-3)

B. Poultry

1. National Poultry and Turkey Improvement Plans. It is estimated that about 3/4 of the chicks and poults produced in the United States in 1962-63 were from the 2,200 hatcheries participating in the Plans. These hatcheries, with capacity for 398 million eggs, used only eggs from breeding flocks which were classified under National Plans standards. All of the 24 thousand flocks, composed of approximately 40 million birds, qualified for a disease control classification, and more than 90% also qualified for a breeding classification. A report of hatchery participation was published early in 1963. This report included the strain identification and the official classification of chicks or poults produced by each hatchery.

The incidence of pullorum and typhoid, as indicated by the number of reactors on first test, reached a new low of .005%. Special reports on the flocks with reactors were initiated during the year. These reports include

information on the history of the flock and premises and conditions which may be related to the infection. Early studies of the reports indicate their potential value as guides for developing a more effective pullorum-typhoid control program. The systematic reporting and investigating of pullorum and typhoid "breaks" have been expanded. Through cooperation of ADE, "breaks" originating from non-plan sources are investigated and corrective measures recommended.

Summaries of reports of Salmonella isolations during the past 5 years reveal a slight downward trend in pullorum and typhoid but a definite increase in the incidence of other Salmonella infections. Greater emphasis has been placed on sanitation practices as a means of controlling these organisms. Pilot programs, using air sampling procedures as a means of evaluating hatchery sanitation, have been initiated in several States. Serological tests have been utilized by some Official State Agencies for the specific control of S. typhimurium in turkeys. These trial programs have demonstrated the effectiveness of this procedure, and similar procedures are anticipated for the National Plans. (AH e5)

2. Random Sample Performance Tests. It is generally agreed that the results of Random Sample Production Tests provide the most reliable information available for use in the evaluation of commercially available poultry stocks. When data from the various tests are treated by accepted statistical procedures to minimize non-genetic influences and combined by stocks, the information becomes even more reliable and more readily applicable as a stock selection guide for commercial poultrymen.

Egg production tests terminating in 1962 submitted data on more than 65,000 hens, representing 185 stocks in the 524 entries tested at 18 testing stations in the United States and four in Canada. The results reported for sixteen traits were evaluated.

The regressed means and least significant difference for each stock and trait were computed. These computations take into account the repeatability between tests, the correlation among replicate pens, number of tests in which a stock is entered, the environmental or non-genetic difference between tests, and the level of performance within each test in relation to the other stocks entered. These statistical adjustments allow predictions to be made of what the average performance would have been for each stock if all stocks had been entered in all tests. The results of these computations were included in a published report which was made available for general distribution.

Seven turkey meat production tests reported data on 100 entries representing 41 stocks. These data were analyzed separately for each test. The performance of each entry and the application of Duncan's Multiple Range Test to 12 traits were published in a report of turkey performance tests. This report also included a summary of test data, combined by stocks, with the regressed mean and LSD Range for each of 15 traits for each stock.

Cooperating broiler tests submitted data on fifty-four thousand birds, representing forty-eight commercial stocks and sixty-two experimental stocks in one hundred eighty-one entries. The entry performance records, without analytical treatment, were included in a published summary. (AH e5)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Dairy Cattle Performance Testing

DHIA Sire Summary List. 1962. ARS-44-122. Part I (Holstein sires; 441 pages) Part II (Ayrshire, Guernsey, Jersey, Brown Swiss, Milking Shorthorn, Red Dane, and Red Poll sires; 509 pages)
DHIA Sire Summary List. 1963. ARS-44-127. (Holstein, Ayrshire, Guernsey, Jersey, Brown Swiss, Milking Shorthorn, and Red Dane sires; 311 pages)
DHIA Lactation Averages. 1962. ARS-44-120.
Dairy Herd Improvement Letters. 1963. ARS 44-118, 119, 121, 123, 124, 125, 126, 128, 129.

Poultry Performance Testing

The National Poultry and Turkey Improvement Plans and Auxiliary Provisions (Revised April 1963). MP 739.
NPIP and NTIP Official State Agencies. CA-44-7.
Report of National Plans Conference. November 1962. Unnumbered.
Breed Distribution of NPIP Participating Flocks by States and Divisions. 1950-51, 1960-61, and 1961-62. ARS 44-2.
Tables on Hatchery and Flock Participation in the National Poultry Improvement Plan by States and Divisions, 1960-61 and 1961-62 and U. S. Summary, 1956-57 to date. ARS 44-3.
Tables on Hatchery and Flock Participation in the National Turkey Improvement Plan by States and Divisions, 1960-61 and 1961-62 and U. S. Summary 1956-57 to date. ARS 44-4.
Hatcheries and Dealers Participating in the National Poultry Improvement Plan. ARS 44-6 and two supplements.
Annual ROP and Performance Test Summary 1961-62. March 1963. ARS 44-7.
Participants in the National Turkey Improvement Plan. ARS 44-8 and one supplement.
Turkey ROP Summary, 1962. ARS 44-10.
Turkeys in NTIP Flocks and Their Distribution by States and Varieties. 1950-51, 1960-61 and 1961-62. ARS 44-11.
Producers of Bantams, Ducks, Geese and Game Birds. CA-44-25.
Poultry Stocks Available for Export by Breeders or Their Agents in the United States. CA-44-51.
Turkey Performance Tests, 1962. ARS 44-13.
Report of Egg Production Tests for the Period 1961-62. ARS 44-79-3.
Chicken Meat Production Tests, 1960-61. September 1962. ARS 44-95-1.
Chicken Meat Production Tests, 1961-62. May 1963. ARS 44-95-2.

AREA 21: PRODUCTION INFLUENCES ON ANIMAL PRODUCTS

Problem. Beef, pork and lamb are excellent sources of wholesome and digestible animal proteins and fatty acids necessary in maintaining a healthy, appetizing diet. However, these meats must be of high quality and in plentiful supply if they are to retain their high position and esteem in the minds of consumers. Proper finish, a high proportion of lean, with adequate intramuscular fat, bright red color, full flavor and tenderness are the goal the meat producer must strive to attain through breeding, feeding and management. The quality of cuts and kind of meat are directly reflected in the demand and in the price of the product.

Color of egg yolk, strength of wool, fatness, quantity, flavor, color and tenderness of meat are all known to be influenced by production practices. However, these quality characteristics and many more are not well understood even though they are of considerable economic importance. Effective measures of evaluating quality differences are of great importance in determining the nature and effect of production practices on the products.

USDA PROGRAM

This is a continuing program conducted by food product technologists, wool and fiber technologists, biochemists, chemists, physiologists, statisticians, and animal husbandmen engaged in both basic and applied research designed to develop methods and information which will be useful in evaluating quality and quantity of animal products and will be useful in aiding and directing livestock production. Research on beef, veal, lamb and pork is directed at the influence of selection and breeding, nutrition, physiology, management, and other production variables on carcass and meat quality and quantity. Standards are being applied and adapted for appraisal of slaughter animals, of carcasses, and of meat cuts. The objective of the work with poultry and eggs is to ascertain those factors of nutrition, breeding, and management which contribute to the initial quality of poultry products and their capacity to retain that quality. Studies with wool, fur, and fiber are conducted to determine the physical, chemical, and biological structures and properties of wool and other animal fibers as influenced by production factors. Research on humane slaughter was initiated to develop information and techniques on preslaughter handling, restraining, immobilizing, and dispatching of hogs, cattle, and sheep, in order to determine the most effective procedures for meeting the requirements of the humane slaughtering law and the influence of the effect of these procedures on the quality of the meat. The work is conducted at Beltsville, Maryland; Dubois, Idaho; Fort Wingate, New Mexico; and in cooperation with eight State experiment stations. Cooperation is also carried out with the Eastern and Western Utilization Research and development Divisions, the Human Nutrition Research Division, and the Market Quality Research Division.

The Federal scientific effort devoted to research in this area totals 16.9 professional man-years. Of this number 5.6 are devoted to beef, 1.2 to lamb, mutton, and chevon, 4.0 to pork, 1.0 to poultry and eggs, 2.1 to wool, fur, and fiber, 1.6 to humane slaughter, and 1.4 to program leadership.

A grant with the Polish Academy of Sciences in Poland provides for studies on the color of pork as influenced by heredity, sex, age, feeding and management. Its duration is for five years (1960-1964) and involves PL 480 funds with $42,784 equivalent to Polish zlotys.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Beef

1. Tenderness. This research is being conducted at Beltsville and in cooperation with the Agricultural Experiment Station of Texas A. and M. University. A contract project with the Agricultural Experiment Station, University of Nebraska, was completed during the year. A contract project with the Market Quality Research Division of AMS was continued.

Studies to develop an accurate measure by evaluation of a biopsy muscle sample was continued with a temporary departure from the "pea-sized" biopsy technique. Samples of Longissimus dorsi muscle approximately 5 cm long and 2 cm wide were surgically removed from the right loin of 21 calves six months of age. The samples were aged 48 hours and evaluated in the raw state for free-amino acid and hydroxyproline. The remaining tissue was heated in deep-fat and evaluated for tenderness using the Slice Tenderness Evaluator (STE) and tenderness press. Panel tenderness scores given by a trained panel on roasts from calves slaughtered the day after biopsy correlated only -.20 with STE values on the heated biopsy samples. The correlation between STE values on roasts and biopsies was .23. Muscle biopsies of similar size have been obtained from 62 cattle at ages six, nine and twelve months. Comparisons will be made between biopsy values and scores for meat from these cattle when slaughtered at finished weight. (AH d4-4)

Continued study in refinements in methodology and additional sampling locations resulted in increased efficiency of the Slice Tenderness Evaluator (STE). The dorsal location in slices of L. dorsi of 9-11 rib roasts from 84 beef cattle was significantly more tender than the medial or lateral locations. In another test highly significant correlations of 0.46, 0.38 and 0.61 were obtained between panel tenderness scores and STE values at the dorsal, medial and lateral locations, respectively. Forty pairs of boneless loin steaks from a group of 40 steers in a breeding-management study were heated to 185° internal temperature in deep fat. One steak from each set was sliced 1/4-inch thick and tested on the STE. Duplicate steaks were evaluated by taste panel and the Warner-Bratzler shear. Simple correlations were quite high among STE, Warner-Bratzler shear and tenderness panel values. Correlation coefficients of -.84 were found between panel

scores and either STE shear or Warner-Bratzler shear readings. Although lower, the relation between STE puncture and panel tenderness scores was expressed by a simple correlation of -.68.

In a study between animals in readings taken at nine body locations, it was found that the relative variation was greater for STE puncture than for STE shear. The three dorsal locations (nearest the midline) were somewhat more tender by STE readings than the medial and dorsal locations, confirming earlier findings. These results were from 44 samples removed from the 6-8 rib roasts obtained from 12-14-month old bulls raised at the U. S. Range Experiment Station at Miles City, Montana. Nine punctures and shears were made from each 1/4-inch slice of meat. These studies were conducted under contract with Market Quality Division, AMS. (MQ 3-34)

Studies are continuing on the paper chromatographic separation of the free amino acids and their relationship to tenderness of beef muscle. During the reporting year, approximately 80 raw and heated samples from the same roast were studied. In addition, 75 biopsy samples were studied. These samples represent cattle that varied in sex, breed, feeding and the use of buffered rations. Interpretation of the curves is underway in order to set a relative value for percent of leucine-isoleucine.

A least squares analysis of variance of the data on hydroxyproline content, the pressure tenderness testing instrument, Warner-Bratzler shear and the palatability committee shows that each measures differences in tenderness between samples and that treatment from birth to six months and ration have a significant effect on tenderness. Calves raised on milk replacer were less tender than those raised on milk the first six months. This difference continued through to slaughter regardless of the kind of finishing ration.

Study was made of the amount of hydroxyproline from connective tissue of the marbling fat and from the lean in the same piece of meat. There is evidence that a difference exists in the hydroxyproline content of the two connective tissues. This indicates a difference in the physical properties of the connective tissue from the two sources. (AH d4-6)

The tenderness press, designed and tested in 1958, was recently modified from an intermittent hydraulic pressure increase system to a continuous hydraulic pressure system. Several safety features have been included. One-inch cores from 19 cooked beef roasts were tested on the press prior to modification. Adjacent cores (frozen) were thawed and tested on the press after its modification. Values averaged 53 pounds higher on the modified press, but variance between samples was decreased to 30 percent of the control. A correlation between original press and panel tenderness scores on the 19 samples studied was -.20. A similar correlation for the data using the modified tenderness press was -.41. In a pilot study involving 14 beef roasts in which panel tenderness scores ranged from 6.2

to 4.0, the panel scores correlated with the modified press and Warner-Bratzler shear values giving correlation coefficients of -.76 and -.59, respectively. (AH d4-4)

Collagen analysis in four muscles, L. dorsi, B. femoris, Semimembranosus, and Semitendinosus has been completed on 28 cattle ranging in age from 220 to 500 days. Results indicated that similar amounts of collagen nitrogen were present in the various ages. The three muscles from the round, B. femoris, Semimembranosus, and Semitendinosus had about the same amount of collagen. The effects of cooking on collagen content was similar in the three muscles. (AH d4-5)

Three years study to evaluate the relationship between certain live animal and carcass characteristics primarily influenced by breeding and tenderness of selected beef cuts was completed at the University of Nebraska as a contract project. Steers used in these tests were from the Fort Robinson Beef Cattle Research Station, fattened at Lincoln and slaughtered as they reached low to middle Choice slaughter grade. Neither live animal weights and measurements nor carcass weights and measurements were of any value in estimating tenderness. The pooled correlation for all steers between carcass grade and shear force was significant ($P < .01$) but low for the animals used in this experiment, which indicated a slight trend for carcasses of higher grades to be more tender. Cartilage density measurements from the ear and spinous process do not appear to have any value in estimating tenderness or maturity development. This contract was completed and terminated. [AH d4-8(c)]

2. Composition. The investigation on application of ultrasonic techniques to live animal evaluation for composition was continued. Results from 183 to 256 cattle ultrasonically measured at points 2, 3, 4 and 5 inches off the midline indicated that subcutaneous fat thickness can be measured more effectively ($r = 0.46$ to 0.61) than L. dorsi area or thickness ($r = -.13$ to 0.31). The muscling of fat cattle seems more difficult to measure ultrasonically than cattle with small amounts of finish. However, fat thickness is more accurately evaluated among finished cattle. Ultrasonic measurements and live weights of 82 beef cattle accounted for 92 percent of the variance in weights of round, rump and loin. But these same variables, ultrasonic fat thickness, ultrasonic lean thickness and live weight, were able to account for only 5 and 13 percent, respectively, of the variance in loin-eye thickness and loin-eye area. The partial regressions of loin-eye area on live weight and ultrasonic lean depth were not significant. The correlation between L. dorsi area at the 12th rib and yield of round, rump and loin was not significant. Ultrasonic measurements are currently being taken on cattle over the mid-short loin, over the last rib junction of bone and cartilage and at two locations on the round. These data will be analyzed soon. These studies were made in cooperation with Agricultural Engineering Division and under contract with the Market Quality Division, AMS. (MQ 3-34)

A study was undertaken to more effectively and accurately estimate live animal composition from linear measurements of the chilled carcass. Assuming that certain cuts were representative of geometric figures, a study was made of the chilled carcass round. The composition of the round has been shown to be closely related to entire body composition. Assuming the round to represent a cone, three linear measurements were employed in computing its volume. These were length, width and thickness. It was found that correlations between computed volume of round and weight of round (rump and shank off) for six month old calves and finished animals were .96 and .83, respectively. Correlations between round weight and total separable carcass lean at six months and slaughter weight were .96 and .93, respectively. Correlations between estimated round volume and carcass lean at six months and market weight were .97 and .80, respectively. This study also showed that carcass lean developed at a significantly faster rate than carcass fat up to six months, but the reverse was true after this. Studies are now being conducted to find good reliable linear measurements on the round of the live animal that will accurately estimate chilled carcass round volume. (AHd-4-7)

3. Quality and quantity of meat as affected by production

(a) Effect of sex. A preliminary analysis of data from yearling bulls and steers from the U. S. Range Livestock Experiment Station indicates that meat samples from bulls were considerably less tender than from steers of similar breeding and age. (AHd-4-7)

(b) Beef from beef, dual-purpose and dairy-type steers. The first group of animals from the study comparing production and meat quality from dairy, dual-purpose and beef steers were slaughtered and the resulting data analyzed. Preliminary analysis of the data show that animals fed on roughage had smaller area of eye muscle, lower dressing yield, less separable fat and more bone. Dairy breeds were highest in percentage of bone in the carcass followed by the Milking Shorthorn and Angus, with the reverse true for separable fat yields. There was a significant breed x ration interaction for thickness of fat over the eye, rib-eye area and percent of internal fat (ruffle, caul and pluck). Palatability scores indicated that ration treatment after six months had no significant effect on the desirability of lean flavor or aroma. Steers fed hay only were less tender, slightly less juicy and received lower overall desirability scores than meat from steers fed concentrate rations. Rib roast samples from the Milking Shorthorn steers in the replicate with no beef-type controls again were the least tender, as measured by the Warner-Bratzler shear. The Jersey beef samples were more tender than the samples from the Holsteins which were intermediate. Panel scores suggest that meat from the Jersey steers was preferred to that of Milking Shorthorn steers, with no difference in juiciness.

Among the second replicate steers, slaughtered at six months of age, ration treatment has again displayed a pronounced effect on tenderness of the meat. Meat samples from animals fed the milk-replacer diet were substantially less tender than meat from the control milk-fed animals. (AH d3-6)

(c) Electrical conductance and quality of meat. The electrical characteristics of beef muscle are being investigated as a possible indicator of beef quality. Electrical properties of 96 beef carcasses measured at periods: 45 minutes, 24 hours, 48 hours and 72 hours post mortem, were compared with taste panel scores for tenderness, quantity of juice, and overall desirability. Comparisons were also made with values from the Warner-Bratzler shear. Amperage and voltage 45 minutes post mortem displayed a significant relationship with tenderness by panel and shear and also with overall desirability of the rib roasts. Correlation coefficients ranged from 0.21 to 0.30. Tenderness, measured by Warner-Bratzler shear, increased as carcass amperage and voltage increased. Significant correlations were found between certain carcass electrical measures at periods 45 minutes, 24 and 48 hours post mortem and tenderness and desirability of the meat. Juiciness apparently was not related to the electrical characteristics. Parallel and series resistance values also were not related to eating qualities. A refinement in measurement technique was necessary to eliminate electrical artifacts associated with motors and electrical circuits in the laboratory. Measurements made on 54 cattle under the new technique are being studied for meat quality indications. (AH d4-4).

B. Lamb

1. Tenderness. The multiple regressions of panel tenderness on organoleptic scores, weight and age in lambs were computed. Also the percent of variation explained by each partial regression was found. The study involved 738 heated leg samples. These data were obtained over a ten year period and involved purebreds, and one, two and three breed crosses. Age, as expected, was negatively associated with tenderness, the older lambs having significantly less tender meat than the younger lambs. It was found that the Southdown lamb samples were consistently more tender than Shropshire, Hampshire or Merino lambs. Also, heated leg samples from one and two breed crosses involving Southdown rams were generally more tender than those corsses involving other breeds of rams. These data are being analyzed more critically to determine more exactly their significance.

The Slice Tenderness Evaluator (STE) has been studied as an objective method for more accurately determining tenderness of heated lamb meat samples. The Gluterus medius and Vastus lateralis muscles offer suitable samples for testing. Preliminary data indicate these muscles are similar in tenderness. It appears that STE values from the G. medius are more indicative of panel tenderness ratings for Semimembranosus than data obtained from the V. lateralis. (AH b6-1)

2. Composition. The estimation of carcass composition from linear carcass measurements, weights, and subjective slaughter and carcass grades was studied. Partial regressions of both live and carcass weight on lean, fat and bone composition of the rib were statistically significant. Of the linear carcass measurements studied, body width, plumpness index and L. dorsi length were significantly related to both lean and total edible portion of the rib. Fat thickness over the L. dorsi muscle, body depth and loin width were significantly related to separable fat of the rib sample. Of the subjective grade factors studied, body finish, both on the live animal and carcass, was significantly related to separable fat of the rib. These data indicated that all but two of the live grade factors and one of the carcass grade factors were strongly associated with weight of lamb in the eyes of the graders, because, after removing the effect due to weight, the variation due to other grade factors was small. (AH b6-1)

Live animal composition studies in lamb were continued, using ultrasonic measurements as the best non-destructive method. A preliminary analysis of the data showed that partial regression of the trimmed leg yield on ultrasonic fat thickness was highly significant. The variables of liveweight, ultrasonic fat thickness and ultrasonic lean thickness accounted for 91 percent of the variability in yield of trimmed leg, but these same three variables could explain only 20 percent of the variability in weight of kidney fat. The partial regressions of lean, fat and edible portion of the rack on ultrasonic measures were not significant. Liveweight variations were able to account for from 49 to 76 percent of the variations in the fat and/or lean components of the rack. This study is being made in cooperation with the Agricultural Engineering Research Division and the Market Quality Research, AMS. (MQ 3-34)

3. Carcass evaluation. An extensive study of carcass data from over 1,100 lambs obtained during the last ten years is underway. The mean squares for the fixed effects of birth year, sex, type of rearing of lamb, age at slaughter and carcass weight showed that: (1) Birth year effects were significant for all factors; (2) sex effects were significant for all factors but one carcass measurement; (3) type of rearing effects was significant for three measurements (leg circumference, length of body and thickness of fat over L. dorsi); (4) age at slaughter effects was significant for body length and loin width.

The least squares constants indicated that rams were narrower, longer, had less L. dorsi thickness and fat over the L. dorsi, were deeper bodied and narrower in the loin area than females. (AH b6-1)

4. Breeding as it affects carcass quality. A large volume of lamb carcass data collected under Western Regional Project W-61 by the Western State Experiment Stations and the U. S. Sheep Experiment Station, Dubois, Idaho, provided the basis for a study of pooled data from a wide variety of environmental conditions and breeding.

The data was obtained from 83 ram lambs including 37 Rambouillets, 23 Columbias, and 23 Targhees. An analysis of variance showed significant breed differences in measurement of bone growth and fatness, the Rambouillets had longer bones, and the Columbias appeared to fatten at an earlier age. Measures of meatiness were not significant in all cases, but when combined into a carcass merit index, differences were found favoring the Columbias. Leg width was the best single live measure of meatiness. Leg width in the carcass was also a good measure of meatiness. Specific gravity measurements of both the carcass and 9-rib rack were poorly correlated with all live and carcass measurements.

Classifiable environmental factors (station, year, age, type of birth, sex, feeding and management) and individual animal variation within breed and environment accounted for most of the variation observed. Breed differences accounted for only a small portion of the total variation in most traits studied. On an intra-environmental basis breed classification became relatively more important, indicating that breeds or breed groups differ to some extent in carcass measurements. The importance of size or weight in carcass traits was further emphasized in the findings of this study.

ARS contributed approximately 15 percent of the data for this study and provided consultation on the data analysis, interpretation and manuscript preparation. The study has been completed. (AH b6-3)

5. Factors affecting carcass merit in fed lambs. A study was conducted at the Southwestern Range and Sheep Breeding Laboratory, Fort Wingate, New Mexico, in cooperation with the New Mexico State University concerning feedlot performance and carcass merit of ram and wether lambs. The ram lambs averaged 2.5 pounds heavier at weaning and 3.4 pounds heavier at slaughter even though they reached slaughter age 5 days sooner than wether lambs. The ram lambs required less feed per pound of gain, made a faster rate of gain and produced more pounds of retail trimmed meat per day of age. These results show ram lambs to be the most desirable from the beeders standpoint; however, it is doubtful if this would be true on the market since buyers are purchasing lambs on the basis of dressing percentage, not cutability.

The effects of various measures of fat content of the lamb carcasses were examined to determine the influence of fat on carcass measurements and measures of retail merit of the lamb carcasses.

The four measures of retail merit were as follows: (1) retail trimmed meat per day of age; (2) retail value per hundred weight of carcass; (3) pounds of retail trimmed meat, and (4) pounds of high priced cuts. It was found that all four measures were highly correlated to each other and in most instances negatively related to the various measures of fat in the carcass when adjusted for hot or cold carcass weight. The various fat measurements were highly related to each other in most instances.

Carcass merit was affected by age of dam, type of birth, and ration. Two and three year old ewes produced leaner lambs with higher yield of retail trimmed cuts than did ewes four years old and older. Lambs from two year old ewes were more tender. Single lambs had smaller loin eye areas than twin lambs. Lambs fed a diet of 70 percent alfalfa, 20 percent milo, and 10 percent molasses, were fatter but lambs fed 100 percent alfalfa were more tender.

The lamb carcasses were sold through a local super market with very good consumer acceptance. The success was attributed to (1) lean, tender cuts that needed little or no trimming, (2) constant supply of fresh lamb, (3) appealing packaging by the supermarket. These results indicate that young, tender, lean lamb will sell very well if a constant supply of fresh cuts is maintained. (AH b1-11, AH b1-12)

C. Pork

1. Tenderness. Studies were continued to determine the relationship of tenderness, juiciness and fatness in pork muscle, prime problems of consumer acceptability. Data on 64 pork-loin samples from high and low fat lines of Yorkshire and Duroc pigs slaughtered at a final weight of approximately 225 pounds were used to determine the value of loin-eye marbling as a factor relating to palatability. Marbling was strongly associated with panel ratings for tenderness and quantity of juice with correlations of 0.61 and 0.86, respectively. The quality of juice and degree of marbling were not significantly related. Color of fresh pork tissue as scored subjectively also was not significantly associated with tenderness.

Results continue to show that with increase in ether extract fat there is an increase in tenderness, juiciness and desirability of flavor of lean. These results were from data on nearly 300 pork loin samples from hogs that varied in average backfat thickness from less than one-inch to three-inches. A least squares analysis showed significant breed differences with respect to intensity of lean flavor, tenderness and quantity of juice.

Tissue electrical capacitance patterns have been recorded for 52 pork carcasses at time intervals of one, five, and twenty-four hours post mortem. Preliminary analysis of the data indicated that fresh pork tissue was less refractory and more able to retain a small electrical stimulus as time post mortem increases.

Study is continuing on the use of the Slice Tenderness Evaluator (STE) as an objective method to more accurately determine tenderness in pork muscle. Slices of cooked pork roasts from 110 samples were tested during the year. The results indicated this method of evaluating tenderness objectively is equal to that of the Warner-Bratzler shear. It was also found that the lateral position of the loin-eye slice was significantly more tender than the medial or dorsal location. This is the opposite reported for beef. (AH a4-3)

2. Composition. Additional analyses of the data from the 97 hogs slaughtered at 50 pound weight intervals from 75 to 275 pounds have been completed. Analysis of variance showed the hams were consistently the best single indicators of total composition, although certain other cuts were more useful at certain stages of development. (AH a4-3)

A study was made to determine if area of ham as measured on the trimmed ham could be utilized effectively to estimate ham composition. The data from 219 hogs were utilized in this study. Analysis of the data indicated that area of ham lean was significantly related to ham lean and area of ham fat to ham fat but the correlations were not too high.

The study of estimated volume of cuts according to their geometric configuration was applied to the square cut, trimmed ham. The ham was considered to be in the shape of a cone. The linear carcass measurements used were: width of right ham, circumference and length. Statistical analysis of the data showed that a high relationship existed between calculated ham volume and weight of separable lean in the ham. Studies are now being made on the live animal in an attempt to accurately calculate ham volume. (AH a4-3)

The fat-lean ratio of pork continues to present a challenge for development of effective, objective techniques for live-animal evaluation. Continued study of ultrasonics as a measure of fat-lean ratio has been underway. Results on 139 fat-lean slaughter weight (215 pound) hogs measured at four points over the back indicated that differences in back-fat thickness between breeds and fat lines within breeds could be detected by this instrument. The simple correlation between the average ultrasonic fat thickness and average actual backfat thickness among the 12 breedline-year group was 0.95. Partial regressions of backfat thickness on ultrasonic measurements at the shoulder and loin were highly significant. However, ultrasonic depth to bone and fat thickness over the last lumbar vertebra were not

significantly effective measures in estimating backfat thickness. Nevertheless, ultrasonic fat thickness values correlated well with actual backfat thickness (r = .71 to .80). Ultrasonic backfat thickness over the loin (at the last thoracic vetebra) was the only ultrasonic value significantly associated by regression with separable fat of the ham. All ultrasonic fat thickness measurements were significantly related to separable lean and to bone of the ham. Simple correlations demonstrating these relationships were from -.52 to -.68 for ultrasonic fat and ham lean and from -.43 to -.51 between ultrasonic fat thickness values and weight of bone in the ham. The thickness of backfat (ultrasonic) was not highly associated with separable fat of the ham since correlations were only .39 and .50. These studies were made in cooperation with Agricultural Engineering Research Division and with Market Quality Division, AMS. (MQ 3-34)

A study was made to determine the changes that might be expected in yields and other important carcass factors when weight was held constant but backfat thickness decreased. A study of 471 hogs, represented by Duroc and Yorkshire breeds, slaughtered at approximately 225 pounds and varying in carcass length (first rib to aitch bone) from 67.2 cm to 86.1 cm (27 - 34.4 inches), showed that with increased length there was a consistent and significant decrease in average backfat thickness and an increase in pounds of lean cuts and lean in the ham until a length of 79.6 cm (31 inches) was reached. At this length there was a leveling off and a decrease in some cases in the pounds of lean. Likewise, the area of loin eye muscle, made at the last rib, increased from 2.6 square inches in Durocs of 67.2 cm to 4.2 square inches at 79.3 cm, then decreased. The same increase in area was found for Yorkshires except the shortest Yorkshire carcasses were 74.1 cm long. It was interesting to note that average area of loin eye muscle was the same for both Durocs and Yorkshires when the carcasses were 79.6 cm long. Above this length the area of loin eye muscle remained the same or decreased. This study indicated that an upper limit on the length of hogs may be desirable. (AH a4-3)

According to results obtained at the Purdue Station, small differences in body composition will be difficult to measure by K-40 techniques unless several counts are made per pig. Usage of the counter will need to be restricted to detailed studies of small numbers, thus limiting usefulness in large genetic studies. Pigs from the 1962 fall and 1963 spring litters have been used at the Purdue Station in a study of the effects of age on various measures of body composition. Results are currently being summarized. Chemical analyses of lean samples from the 1961 fall pigs will soon be completed. Means by sex of pigs in the animal house on high and low protein and at the farm on normal protein were examined. Location effect was significant ($P < .10$) for percent moisture in the right ham, with those reared in the animal house averaging 12 percent higher moisture. Females had a greater loin eye area ($P < .05$) and thicker backfat ($P < .10$) than

males. Protein level did not significantly affect any of the traits measured. Correlations of live animal potassium values (K-40) with physical and chemical measures of body composition indicated that small differences between individual pigs are not easily detected by the liquid scintillation counter. (AH a1-18)

3. Carcass Evaluation. Studies of the ability of panels of judges to differentiate between live hogs and their carcasses for economically important characteristics have been made at the Michigan Station using a paired comparison technique. Judges of live hogs tended to be more consistent in their judgments than did those of carcasses and more nearly achieved a perfect ranking of the seven hogs comprising each batch. However, the carcass judges showed a marked improvement as the experiment progressed. Both panels of judges found it more difficult to make consistent judgments of the percent yield of untrimmed loin than of rib-eye area or of the yield of trimmed lean cuts. Rankings of live hogs for the yield of untrimmed loin showed a very small relation to the actual yield of this cut, and only a slight relation for the carcass judges. Rankings of live hogs and carcasses for rib-eye area and the yield of trimmed lean cuts were both significantly related to these characteristics although, in the case of lean cut yield, the judges' predictions were no better than could have been achieved using backfat measurements. (AH a1-14)

An analysis at the Oklahoma Station of side to side variation in the physical separations and measurements of 42 swine carcasses indicated that specific gravities of the carcass and the ham, and linear measurements of backfat and length could be accurately taken from one side of the carcass. Cross sectional tracings at eight points indicated that area measurements of fat and of lean were more accurately obtained in the midregion of the carcass compared with either extremity. Division of the ham from the carcass and subsequent separation into fat, lean and bone were more accurate than were division and separation of the middle and shoulder. Measurements of these carcasses indicated that carcass length was of little value as an index of percent separable lean ($r^2 = 0.06$), and was of no value if carcass backfat was also considered. The leanmeter better indicated leanness ($r^2 = 0.48$) than did carcass backfat thickness ($r^2 = 0.36$), but was inferior to carcass backfat thickness and loin-eye area at the tenth rib ($R^2 = 0.70$). Specific gravity of the ham was a good index of leanness ($r^2 = 0.69$) and mutually supplemented loin-eye area ($R^2 = 0.79$). The weights of lean and fat in the ham were highly associated with leanness ($R^2 = 0.92$). The variance in percent lean accounted for by weight of cross section samples at different locations and their area components of fat and lean were 79% for the second thoracic vertebra; 81% for the sixth thoracic vertebra; 85% for the tenth thoracic vertebra; 77% for the fourteenth thoracic vertebra; 89% for the third lumbar vertebra; 77% for the second sacral vertebra; 81% for the center of the ham; and 72% for the shank of the ham. The indices generally showed a lower relation with weight of separable lean than with percent of separable lean. They were associated, however, more closely with leanness than with the protein of the lean. (AH a1-8)

The relationships between body length and other carcass traits were studied at the Nebraska Station. Body length was positively associated with all traits except backfat thickness. Longissimus dorsi mass increased with length without an appreciable reduction in cross sectional area. Length x area was superior to either trait separately in predicting trimmed cut yield. Weight of the L. dorsi was more closely associated with loin weight or lean cut weight than L. dorsi area. These results provide a more critical appraisal of the influence of length on loin muscle mass than has been available previously. (AHal-7)

4. Color. Research on color in pork as influenced by heredity, sex, age, feeding and management was continued as a PL 480 study with the Institute of Animal Physiology and Nutrition, Laboratory for Animal Products, Polish Academy of Science, Warsaw, Poland. The second progress report indicated it is not necessary to measure the total reflectance spectrum of the meat surface. It is sufficient to measure the reflectances at 550 and 640 mu and to calculate the values for lightness and dominant wave length of color from the regression equations. Accurate measurements of pork color indicated that various meats differed in all color attributes and not only in lightness as has been sometimes thought. Feeding experiments showed that the increased protein: carbohydrates ratio in the diet does not diminish the values for color and pigments in meat of pigs slaughtered at the same live weight. The increased pig rations with the same protein: carbohydrate ratio produced significantly paler meats with less pigment content. It was found that the level of protein in the ration influenced water content, protein content, water-holding capacity, myoglobin concentration and water-soluble SH-group in meat. Steps are being taken to study glycolysis in the meat of animals 45 minutes post mortem to determine if this enzymatic activity is in any way related to white muscle disease. (E 21-AH-2, PL 480)

D. Poultry and Eggs

New methods have been developed in protein biochemistry to separate and purify the individual proteins. These techniques have been applied to separate the proteins of egg albumen and yolk with conflicting results. Cellulose ion exchange chromatography and zone electrophoresis on paper and gel are being compared with neutral salt precipitations. By using starch gel electrophoresis, blood serum proteins have been found in egg albumen and yolk. Other techniques should be used to confirm these observations and evaluate the differences in relation to other studies on eggs. (AH e4-10)

E. Wool and Fiber

1. Factors affecting quality and value of wool. Fleeces from 24 Columbia ewes selected because of their coarse wool at weaning age in 1957 were studied throughout their lifetime at Dubois, Idaho, in informal cooperation with regional project WM-23, Marketing of Western Wools. Quality traits and processing characteristics of the fleeces were studied to determine their desirability as Columbia fleeces and to follow changes in subsequent years. Fleeces on the coarse wool Columbia ewes became coarser from 2 to 3 to 4 years of age. Fibers from the thigh area were coarser than those from the side by 3.0, 3.3, 2.7 and 2.8 microns for each of the 4 ages, respectively. Weight of grease wool, clean wool, and top increased to the third year and then declined slightly for the fourth year of age. Diameter and length of fiber in the top increased over the 4 years of age. A control lot of 24 Columbia ewes with finer fleeces, which had acceptable wool fineness for Columbias at weaning age, was also studied. The control fleeces also became coarser from one to 4 years but slightly less than the coarse fleeces. Data obtained during the lifetime of these sheep or until they reached maximum wool production are being summarized.

Investigation of the relationship between quality traits and the economic returns from wool at Dubois, Idaho, was continued in 1962. The 64/70's quality fleeces were classed into two lots according to length of staple. One lot each of 60/62's, 56/58's, 50/54's and 46/48's quality fleeces were studied. Staple length and fiber diameter were determined from measurements of 100 hook staples drawn from each lot. Clean fiber and vegetable matter content were determined by the core test. Average staple length of the 64/70's quality fleeces classed as staple wool was 0.6 inches longer and the average fiber diameter was 0.3 microns coarser than the 64/70's fleeces classed as French wool. The 64/70's staple (mature ewe) fleeces were 1.2 pound heavier and had 2.8 percent higher clean yield than the 64/70's French fleeces. The 64/70's staple wool sold for 62 cents a grease pound compared to 53 cents for the 64/70's French wool. The 60/62's and 56/58's quality fleeces were all classed as staple wool with an average staple length of 3.4 and 3.7 inches, respectively. The average fiber diameter of the 60/62's and 56/58's fleeces was 23.4 microns and 26.4 microns, respectively. The fleeces classed as 50/54's and 46/48's made up lots too small to be useful for price comparisons. One variable grade line of fine and medium wools was made up and sold as original bag wool. Wools of uniform quality sold for 2.9 cents more per grease pound than variable grade lines. (AH b5-2)

2. Measuring methods to evaluate wool. Methods of measuring wool crimp are being investigated at Beltsville, Maryland. A reasonably accurate and fast method of measuring crimp in individual fleeces is needed to determine its value in selection. Preliminary experiments indicated the need for additional information on variability among locks within regions on the sheep, operator and subsample differences. Duplicate grease wool locks were randomly chosen from the shoulder, back, and thigh of each of five Merino rams, Merino ewes, Shropshire rams, and Shropshire ewes. It was concluded that two operators, each making one run, would be sufficient. Width/depth ratio and number of crimps per inch were calculated. Crimps per inch were also measured by ruler. Comparison of these methods showed low correlations of ruler with measures of individual crimp between subsamples within sheep, operator, location, level and lock and between locks with sheep, operator, location and level but high correlations on a between-sheep basis.

An attempt was made to decrease the time involved in measuring and to increase accuracy by devising a scale to determine width/depth ratio and number of crimp directly from the projected image. Results were read from a triangular scale superimposed on the projected crimp. Two operators used the scale on the same set of slides from the previous experiments. Results indicated that the scale measurements were quite similar to those by the other two methods with slightly lower coefficients of variability for the width/depth ratio and higher coefficients for crimps per inch. Level, lock and subsample differences were still important sources of error for each method. Determinations by location on the sheep and by level on the lock were of similar magnitude and in the same direction for each method.

More rapid and less expensive methods of measuring wool fiber length are being investigated at Beltsville, Maryland. Length of wool fiber is important in evaluating fleeces from individual sheep for use in selection programs for wool improvement. The Suter Stapler, used for length determinations by combing a sample into 1/2-inch classes and weighing each class, is slow and tedious. The Digital Fibrograph, using the photoelectric scanning principle for evaluating cotton from a length standpoint, might be adapted to provide a more rapid measurement of wool length. A sample of top is squared off and placed on the Fibrograph combs to give a thin array of fibers. Results from the Digital Fibrograph were compared with those from the Suter Stapler. Random samples of top from 47 Rambouillet, 26 Targhee and 26 Columbia fleeces, processed at Beltsville, were studied. The mean fiber length values with the Fibrograph were 1.09, 1.20, and 1.21 for Rambouillet, Targhee and Columbia top compared with 1.95, 2.13, and 2.24 inches obtained with the Suter Stapler. The respective standard deviations were .61, .66, and .71 compared with .87, .95, and 1.04. Differences between the two methods for the means and the standard deviations increase as average length increases. Linear correlations on a between-fleece basis were .48, .79, and .56 for the three breeds, respectively. Corresponding correlations for standard deviations were .79, .81, and .19.

The relatively low correlations may have resulted from the present Fibrograph design, which is limited to a 4-inch field. Further work is needed on the relation of the Fibrograph to other direct measures of fiber length.

Research on adaptation of the Coulter Counter for use in measuring the fineness and variability of wool fibers is progressing at Beltsville. The problems with changes in temperature, improper stirring, and blockage of the aperture tube encountered with the Model A instrument have been eliminated from the Model C instrument now at Beltsville. The main problem is still the cutting of the wool samples to lengths with known and/or acceptable tolerance. A cutting instrument has been devised and constructed and is being tested for reliability in cutting fibers to uniform lengths.

The Electronic Fiber Fineness Indicator to measure fiber diameter and its variability is being improved and evaluated under contract at Knoxville, Tennessee. The principle used in the Fiber Alignment Device has been incorporated into E.F.F.I. along with revisions in the circuitry. The instrument is now ready for testing. (AH b5-3-Rev.C.)

3. Relation of fleece traits to processing characteristics. Fourteen grade-breed lots from Dubois, Idaho, each containing 15 mature ewe fleeces visually grading the same, were studied to investigate further relationships among quality traits of grease wool to processing characteristics, yield and quality of top. Each grade-breed lot was sampled in the grease, scoured at the University of Wyoming Wool Laboratory and processed into top at Philadelphia Textile Institute. Data from the first year indicate that as the fiber diameter of grease wool increases within a breed, staple length increases, number of crimps per inch decrease, grease fleece weight increases, clean yield becomes higher, top yield per pound of clean wool increases, and variability of both fiber length and diameter in the top becomes greater. Columbia wool was slightly longer, had fewer crimps per inch, and was coarser than Targhee wool of the same visual grade. Targhee wool was longer, had fewer crimps per inch and was coarser than Rambouillet wool of the same visual grade. This study is being continued until sufficient data are available for more decisive results. (AH b5-7)

F. Humane Slaughter

1. Cornell University. Research was continued at Cornell University to determine the physiological effect of immobilization with different percentages of carbon dioxide mixed with air or oxygen and to study the effects of carbon dioxide upon bleeding and carcass quality. Results of these studies indicated that the arterial blood pressure, pluse pressure, and heart rate of both sheep and swine were increased when the animals were immobilized with gas mixtures containing 75% CO_2 and 5, 15 or 25% O_2. Under the experimental conditions, an increase of O_2 in the immobilizing gas mixture permitted exposure of the animals to the gas mixture for considerable longer periods of time without detrimental effects. Carcass observations indicated that blood yield of swine slaughtered after immobilization with a gas mixture containing 75% CO_2 and either 5 or 15 percent O_2 was significantly higher on a carcass weight basis than was blood yield of like animals slaughtered without immobilization. This may be due to less blood being retained in the circulatory system of the immobilized animal. Color and pH measurements taken from the Longissimus dorsi muscle of these animals indicated that the experimental treatments failed to produce any significant change in the color of the muscle at three, twenty-four or forty-eight hours after slaughter. The CO_2 gas treatments, however, appeared to retard the rate of acid production in the immobilized animals. The difference in muscle pH was greatest three hours after slaughter and gradually diminished over a period of forty-eight hours. The overall observation was the satisfactory use of CO_2 for immobilization of both sheep and swine. Most animals appeared to lose consciousness within 30 seconds with a one-minute period as adequate. Minimal exposures to the gas mixture appeared essential to minimize petechial hemorrhages in the organs, diaphragm and neck muscles. This work has been discontinued. (AH j1-1)

2. Beltsville, Maryland. Considering the difficulty with which response to pain can be measured, as a result of either mechanical or electrical stunning, it was decided to attempt to find some metabolic response to the stress thought to be inflicted upon the animal during slaughter. A consistent display of some type of metabolic stress at the time of slaughter might then be used to evaluate immobilizing procedures. The minimum amount of "internal stress" brought about by a particular treatment previous to slaughter may be a better indication of an animal's "well being" than the ill-defined response to pain. It has been shown that stresses due to anoxia, heat and cold resulted in increases in the potassium content of the extracellular fluids and decreases in potassium content of the tissues. The adrenalglands may have a role in some of these changes. Research studies were initiated to discover if these changes could be attributed to the preslaughter stress. It was soon evident that extensive hemolysis in the hog serum samples would prevent a valid estimation of the serum potassium content. After attempting several corrective procedures to eliminate the appearance of hemolysis,

it was decided to investigate the possibility of hemolysis being associated with immobilizing procedures. Preliminary data indicated that stunning market-weight hogs caused the appearance of hemolysis in the serum samples. Bleeding the hog with no stunning produced much less evidence of hemolysis. In the younger hogs, 150 pounds or less, stunning electrically produced an increase in the amount of hemolysis present in the serum samples, but the effect was less pronounced than in the older market-weight hogs. The use of the captive bolt for stunning hogs showed less hemolysis in the younger hogs than did electrical stunning.

Observations at the time of slaughter indicated that the appearance of hemolysis appears to be associated with rather severe muscular contractions associated with a particular treatment or stunning process. Hogs anesthetised previous to slaughter showed little evidence of hemolysis in their serum samples. The lack of hemolysis was clearly evident in the serum from hogs that had not been immobilized previous to bleeding.

Similar studies have been made with lambs, but the results indicated that the serum samples from lambs immobilized by either electrical shock or the captive bolt were free from hemolysis. This might suggest that there is some basic difference between the two species in their response to pre-slaughter stress. This difference might be found in the erythrocyte cell walls.

This research study was discontinued. (AH j1-2)

3. University of Minnesota. Investigations were continued in the complex problem of determining if an animal feels pain upon being immobilized by the use of electrical current applied to the frontal section of the head. The results of the study of pain perception indicated that conditional procedures are useful in the study of pain perception in animals. Electrical stunning, using sufficient intensity of current, resulted in the animal being unable to perceive pain for 3 - 10 minutes. Electrical stunning in itself was not painful to the animal, and, electrical stunning, if of sufficient intensity, produced a retrograde amnesia of events occurring within one minute of the stunning procedure. (AH j1-3)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Beef

Alsmeyer, R. H., Kulwich, R. and Hiner, R. L. 1962. Loin-eye tenderness variations measured by the STE. J. Animal Sci., 21:977. (Abstract). (MQ 3-34).

Alsmeyer, R. H., Hiner, R. L. and Thornton, J. W. 1963. Ultrasonic measurements of fat and muscle thickness of cattle and swine. Annals N. Y. Acad. Sci. (In press). (MQ 3-34).

Alsmeyer, R. H. 1963. Results of ultrasonic research on beef cattle in the United States. Presented at the 16th Reciprocal Meat Conference, Stillwater, Oklahoma, June 11-13, 1963. (MQ 3-34)
Ritchey, S. J., Cover, Sylvia and Hostetler, R. L. 1963. Collagen content and its relation to tenderness of connective tissue in two beef muscles. Food Tech., 17(2):76-79. (AH d4-5)
Kieffer, N. M., Brinks, J. S., Hiner, R. L. and Clark, R. T. 1962. Comparison of straightbred and crossbred steers for certain performance and carcass traits. J. Animal Sci., 21(3):664. (Abstract) (AH d4-7)

Lamb

Marchello, J. A. and Cramer, D. A. 1962. Composition of ovine fat; II. Genetic differences. J. Animal Sci., 21(4):983-984. (Abstract) (AH b6-1)
Stanley, Marion E. 1962. Live and carcass measurements as predictors of meatiness in lambs. Ph.D. Thesis, University of Wyoming. (AH b6-3)

Pork

Bowman, G. H., Whatley, Jr., J. A. and Walters, L. E. 1962. Physical indices of leanness in swine. J. Animal Sci., 21:955-959. (AH a1-8)
Bowman, G. H., Whatley, Jr., J. A. and Walters, L. E. 1962. Separation and measuring errors in swine carcasses. J. Animal Sci., 21:950-954. (AH a1-8)
Bowman, Gordon H. 1962. Measures of leanness in swine. Ph.D. Thesis. Oklahoma State University Libr., Stillwater. (AH a1-8)
Feinstein, L. and Hiner, R. L. 1963. Anesthesia and its relationship to body composition. Presented at the Conference on Body Composition, N. Y. Acad. Sci. Meetings, January 1963. (AH a4-3)
Harrington, G., Pearson, A. M., and Magee, W. T. 1963. Subjective evaluations of cutting yields and rib-eye area in live hogs and carcasses. J. Animal Sci., 22:169-172. (AH a1-14)
Hiner, R. L. and Thornton, J. W. 1962. Carcass length effect on pork yields and composition. J. Animal Sci., 21(4):982. (Abstract) (AH a4-3)
Johnson, E. K., Hiner, R. L., Alsmeyer, R. H., Campbell, L. E., Platt, W. T. and Webb, J. C. Paper read at the 1963 annual meeting of American Society of Agricultural Engineers, June 23-26, 1963. (MQ 3-34)
Janicki, M. A. 1963. Myoglobin and hydration of meat in pigs. Roczniki Nauk Rolniczych. (20-C-3)
Martin, T. G., Kessler, W. V., Stant, Jr., E. G., Christian, J. E., and Andrews, F. N. 1963. Body composition of calves and pigs measured by large volume liquid scintillation counting and conventional chemical analyses. Proc. Symp. on Body Comp. N. Y. Acad. Sci. (In press) (AH a1-3)

Martin, T. G., Garwood, V. A., Kessler, W. V., Christian, J. E., and Andrews, F. N. 1963. The influence of ration on body composition of growing farm animals. Proc. Symp. on Body Comp., N. Y. Acad. Sci. (In press). (AH a1-3)

Wool and Fiber

Wilson, L. O., Price, D. A. and Blackwell, R. L. 1962. Relationship of lamb birthcoat to fleece and body traits. J. Animal Sci., 21(3): 663-664. (Abstract). (AH b5-7)

Humane Slaughter

Breazile, J. E., Naitoh, Y. and Kitchell, R. L. 1963. Minnesota Farm and Home Science, 20(2):3-4. (AH j1-3)

Kitchell, R. L. 1963. Methodological considerations for assessment of pain perception in animals. Reprinted from Proc. Vet. Med. Conf., UFAW Symposium, held in London, England, July 1962. (AH j1-3)

Breazile, J. E., Kitchell, R. L. and Naitoh, Y. 1963. Neural bases of pain in animals. Paper read at the 15th Annual Research Conference, American Meat Institute Foundation, March 21-22, 1963. (AH j1-3)

Travis, H. F., Johnson, E., Whitmore, G., Bollinger, N. and Hiner, R. L. 1963. Some physiological effects of the mechanical immobilization of sheep. (Manuscript prepared). (AH j1-2)

Line Project Check List -- Reporting Year July 1, 1962 to June 30, 1963

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in Summary of Progress	Line Proj. Incl. in Area & Sub-Subheading
AH a1	Swine Breeding Investigations				
AH a1-3*	Development of inbred lines within Duroc, Chester White and Landroc swine and various crosses	Lafayette and Wanatah, Ind.	V. A. Garwood and C. E. Shelby	No	
AH a1-4	Improvement of swine through breeding	Ames and Ankeny, Iowa	L. N. Hazel & C. E. Shelby	Yes	16-A-1
AH a1-6	Effectiveness of selection for swine carcass quality based on backfat thickness	Columbia, Mo.	J. F. Lasley and C. E. Shelby	Yes	16-A-1 16-B-1,6 17-A-2
AH a1-7	Breeding for improvement of economic traits in swine - purebred and crossbred foundation stocks	North Platte & Lincoln, Nebr.	L. J. Sumption and C. E. Shelby	Yes	16-B-5,6 17-A-2 21-C-3
AH a1-8	Selection for combining ability of three lines of swine	Stillwater & Ft. Reno,Okla.	J. A. Whatley, Jr., and C. E. Shelby	Yes	16-A-1 16-C 17-A-2 21-C-3
AH a1-9	Inbreeding, linecrossing and selection within and between the Hampshire, Duroc and Yorkshire breeds of swine	Brookings, Eureka & Centerville, S. Dak.	J. W. McCarty & C. E. Shelby	Yes	16-B-1,3,6
AH a1-10	Methods of breeding and selection in swine	Madison, Wis.	A. B. Chapman & C. E. Shelby	Yes	17-A-1,2
AH a1-11	Recurrent reciprocal selection for high specific combining ability in crosses between Yorkshire and Mont. No. 1 swine	Miles City, Mont.	C. M. Kincaid, H. O. Hetzer & C. O. Miller	Yes	16-B-2
AH a1-12	Selection for high and low degrees of fatness in swine	Beltsville, Md.	C. M. Kincaid & H. O. Hetzer	Yes	16-A-1 16-B-1
AH a1-13	Reciprocal recurrent selection for general and specific combining ability in two strains of swine	Beltsville, Md.	C. M. Kincaid & H. O. Hetzer	Yes	16-A-1
AH a1-14	Use of rapid inbreeding with selection in evaluating and utilizing potential sources of superior germ plasm	East Lansing, Mich.	W. T. Magee & C. E. Shelby	Yes	16-B-3,4 21-C-3
AH a1-15*	Swine metabolism investigations	Beltsville, Md.	C. M. Kincaid	No	
AH a1-16	Effectiveness of selection in purebred and crossbred foundation stocks	Urbana, Ill.	H. W. Norton & C. E. Shelby	No	
AH a1-17	Selection, inbreeding and crossing for swine improvement	St. Paul, Crookston, Duluth,Grand Rapids,Morris, Rosemount & Waseca, Minn.	R. E. Comstock, W. E. Rempel & C. E. Shelby	Yes	16-A-1,2 16-B-1
AH a1-18**	A comparison of selection procedures within lines of swine used for cross-breeding	Lafayette & Farmland,Ind.	V. A. Garwood & C. E. Shelby	Yes	21-C-3
AH a1-19**	Exploration of metabolic pathways that interrelate biochemical and genetic differences in swine populations	Beltsville, Md.	C. M. Kincaid	No	
AH a2	Swine Management Investigations				
AH a2-3	Evaluation of new or improved types of hog rearing equipment	Beltsville, Md.	C. M. Kincaid & J. W. Stevenson	No	
AH a2-4	Evaluation of pasture and harvested forage in swine production	Beltsville, Md.	C. M. Kincaid & J. W. Stevenson	Yes	18-A-1 18-C
AH a3	Swine Feeding and Nutrition Investigations				
AH a3-12	Trace mineral requirements and biochemical pathways relating to mineral utilization by swine	Beltsville, Md.	I. P. Earle & J. W. Stevenson	Yes	18-D-1,2,3,4

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in Summary of Progress	Line Proj. Incl. in Area & Sub-Subheading
AH a3-14*	The interrelations of nutritional and metabolic status with susceptibility of the baby pig to specific infectious diseases	East Lansing, Mich.		No	
AH a3-16*	Improving the safety and use of cotton-seed meal as a swine feed	Beltsville, Md.		Yes	18-B
AH a4	Pork Studies				
AH a4-3	Meat characteristics of carcasses of pork developed through breeding, nutrition and management	Beltsville, Md.	R. L. Hiner	Yes	21-C-1,2,3
	* Discontinued during reporting year ** Initiated during reporting year				

Line Project Check List -- Reporting Year July 1, 1962, to June 30, 1963

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in Summary of Progress	Line Proj. Incl. in Area & Sub-Subheading
AH b1	Sheep Breeding Investigations				
AH b1-1	Selective mating and breed comparisons of sheep for farming regions.	Beltsville, Md.	G. M. Sidwell, C. E. Terrill	Yes	12 B 1
AH b1-2	Lamb and wool production from crossbred sheep from the Hampshire, Shropshire and Southdown breeds.	Beltsville, Md.	G. M. Sidwell, C. E. Terrill	Yes	12 B 1
AH b1-3	Development of a strain of sheep for maximum production of lambs and wool under farm conditions.	Beltsville, Md., Middlebury, Vt.	G. M. Sidwell, C. E. Terrill	Yes	12 B 1
AH b1-4	Selecting and crossbreeding of Merino sheep for increased productivity.	Beltsville, Md.	G. M. Sidwell, C. E. Terrill	Yes	12 B 1
AH b1-5	Investigations of systems of breeding for improvement of range sheep.	Dubois, Idaho	S.K. Ercanbrack, R.L. Blackwell	Yes	12 B 3 and 4
AH b1-6	Investigations of traits for use in breeding and selection of range sheep.	Dubois, Idaho, Bozeman, Mont.	S.K. Ercanbrack, R.L.Blackwell	Yes	12 A 1
AH b1-7	Studies in physiology of reproduction of range sheep.	Dubois, Idaho, Logan, Utah	C. A. Hulet, R.L. Blackwell	Yes	13 A, 1,2, 3, 4, 5
AH b1-8	Occurrence of estrus in sheep as related to reproductive performance.	Beltsville, Md.	G.M. Sidwell C.E. Terrill, I.L. Lindahl	No	
AH b1-10	Improvement of Navajo sheep by line breeding and selection within the Navajo strain.	Ft.Wingate,N.M.	S. L. Smith, T. H. Hall	Yes	12 A 2
AH b1-11	Improvement of fine wool sheep under Southwest conditions.	Ft. Wingate and Univ.Park,N.M.	S. L. Smith, T. H. Hall, E. E. Ray, R. Mandigo	Yes	12 A 2, 21 B 5
AH b1-12	Improvement of coarse wool sheep for the production of wool suitable for Navajo hand weaving.	Ft. Wingate, Univ.Park,N.M.	S. L. Smith, T. H. Hall, E. E. Ray, R. Mandigo	Yes	12 A 2, 21 B 5
AH b1-13	Influences of breeding on efficiency of gains in range sheep.	Dubois, Idaho	K.R.Frederiksen, D. A. Price and R. L.Blackwell	Yes	12 A 3
AH b1-14	Testing of inbred lines of sheep through top crossing.	Dubois, Idaho, Bozeman, Mont.	S.K. Ercanbrack, R. L. Blackwell	Yes	12 A 1, B 4
AH b1-15	Investigations of blood group relationships in sheep.	Dubois, Idaho, Davis, Calif.	C. L. Stormont, R. L. Blackwell	Yes	12 A 5
AH b1-16	Improvement of commercial range sheep through breeding and selection.	La Sal and Logan, Utah; Ft. Collins, Colo.; Ft.Wingate, N.M., Beltsville, Md.	G. M. Sidwell, T. H. Hall	Yes	12 B 5
AH b1-17	Development by selective breeding of a strain of sheep which will reproduce more often than once per year and without seasonal restriction.	Beltsville, Md.	G. M. Sidwell, C. E. Terrill, I. L. Lindahl	Yes	12 B 2, 13 A 6
AH b2	Sheep feeding investigations				
AH b2-1 (d2-31)	The cause and prevention of urinary calculi in fattening beef cattle and sheep.	College Sta., Big Springs, Tex.	H. R. Crookshank and I. L. Lindahl	Yes	14 A 1
AH b2-5	Factors in the utilization of pelleted feeds by sheep and other ruminants.	Beltsville, Md.	I. L. Lindahl, P. J. Reynolds, C. E. Terrill	Yes	14 A 2, 3
AH b2-6	Investigations of physiological reactions of sheep and other ruminants in relation to metabolic disorders.	Beltsville, Md.	I. L. Lindahl	No	
AH b2-7	Investigations on the utilization of forage by sheep.	Beltsville, Md.	I. L. Lindahl, P. J. Reynolds	No	
AH b2-8	Investigations on the nutritive value of new or improved forages.	Beltsville, Md.	I. L. Lindahl, P. J. Reynolds	No	

Line Project Check List -- Reporting Year July 1, 1962, to June 30, 1963

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl.in Summary of Progress	Line Proj. Incl.in Area & Sub-Subheading
AH b3	Sheep management investigations				
AH b3-1	Investigations of sheep grazing management on ranges of the Intermountain region.	Dubois, Idaho	D. A. Price, R. D. Humphrey, R. L. Blackwell	No	
AH b3-4	The response of Targhee sheep to different environments.	Hawaii; Dubois and Moscow, Idaho; Ft. Wingate, N.M.; Spooner, Wisc., Beltsville, Md.	C. E. Terrill	Yes	13-B-1
AH b3-5	The effect of shearing, light and season on rate of wool growth.	Beltsville, Md.	M. E. Hourihan, C. E. Terrill	No	
AH b3-7	Methods of producing milk fat "spring" lambs.	Ft. Reno, Okla.	J. V. Whiteman, Jr., I. L. Lindahl, C. E. Terrill	Yes	12-A-4, B-6, 14-A-2
AH b3-8	Influence of environment at different geographic locations on fleece and body traits of sheep.	Beltsville, Md.	C. E. Terrill	No	
AH b3-9	Investigation of nutrition and management of range sheep.	Dubois, Idaho	D. A. Price, R. D. Humphrey, R. L. Blackwell	Yes	14-A-2, B-1
AH b3-10	Comparative productivity of pastures grazed by beef cattle alone, sheep alone and by the two species in combination.	Beltsville, Md.	I. L. Lindahl P. J. Reynolds	Yes	14-C-1
AH b3-11	Influence of management practices on internal parasitism of lambs.	Beltsville, Md.	I. L. Lindahl, C. E. Terrill	Yes	14-C-2
AH b4	Goat nutrition investigations				
AH b4-3	Investigation of dairy goat production.	Beltsville, Md.	I. L. Lindahl, C. E. Terrill	No	
AH b5	Investigations of wool and other animal fibers				
AH b5-1	Growth and development of the skin, fibers and accessory follicular structures in goats.	Beltsville, Md., McGregor, Texas	L. M. Hansen E. H. Dolnick	Yes	13-C-1,2
AH b5-2	Factors affecting the quality and value of wool.	Dubois, Idaho, Beltsville, Md.	L. O. Wilson, R. L. Blackwell M. E. Hourihan, C. E. Terrill	Yes	21-E-1
AH b5-3 Rev. C	Evaluation of wool from farm sheep for breeding, nutrition and management studies.	Beltsville, Md., Knoxville, Tenn.	M. E. Hourihan, C. E. Terrill	Yes	21-E-2
AH b5-5	Influence of age and season on the skin and follicular structures associated with shedding in Angora goats.	Beltsville, Md., McGregor, Texas	L. M. Hansen, E. H. Dolnick	Yes	13-C-3
AH b5-6	Investigations of wool for the improvement of Navajo, Navajo crossbred, Targhee and Targhee crossbred sheep under Southwest range conditions.	Fort Wingate, New Mexico	T. H. Hall, S. L. Smith	Yes	12-A-2,
AH b5-7	Relation of fleece traits to processing characteristics, yield, and quality of card sliver and top.	Dubois, Idaho, Beltsville, Md.	M. E. Hourihan, L. O. Wilson, R. L. Blackwell, C. E. Terrill	Yes	21-E-3
AH b6	Mutton, lamb and chevon studies				
AH b6-1	Meat characteristics of carcasses of lambs representing certain breeds and crosses	Beltsville, Md.	R. L. Hiner	Yes	21-B-1,2, & 3
AH b6-3C*	Evaluation of meat characteristics of lamb carcasses and their relationship to live animal characteristics for genetic studies.	Dubois, Idaho; Laramie, Wyo. Beltsville, Md.	C. E. Terrill, R. L. Hiner, R. L. Blackwell, S. K. Eranbrach, P. O. Stratton, C. O. Schoonover	Yes	21-B 4

* Discontinued

Line Project Check List -- Reporting Year July 1, 1962, to June 30, 1963

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Project Incl. in Summary of Progress	Line Project Incl. in Area & Sub Subheading
AH d1	Beef and Dual-Purpose Cattle Breeding Investigations				
AH d1-1 (rev.#2)	Breed crossing for increased production in beef cattle.	Miles City, Mont.	N. M. Kieffer	Yes	2-C-1
AH d1-2 (rev.#2)	Development of superior lines of beef cattle.	" " "	N. M. Kieffer	Yes	2-A-1,2,7 2-B-1,2 2-C-2
AH d1-3 (rev.)	The development of more efficient beef cattle for Georgia through the use of selection, progeny testing, inbreeding and cross-breeding.	Tifton, Ga. Reedsville, Ga.	B. L. Southwell W. C. McCormick	Yes	2-C-1
AH d1-4 (rev.)	The improvement of beef cattle for Virginia through breeding methods.	Front Royal and Blacksburg, Va.	B. M. Priode K. P. Bovard	Yes	2-A-7 2-C-2
AH d1-5 (rev.)	Selection of cattle adapted to beef production in Southeastern United States.	Brooksville, Fla.	W. C. Burns Marvin Koger	No	
AH d1-6 (rev.)	Development of pure and crossbred types of cattle for Southeastern United States and the Gulf Coast Region.	Jeanerette, La.	J. W. High, Jr.	Yes	2-A-4 2-B-2 3-A-5
AH d1-7 (rev.)	Heterosis from crosses among British breeds of beef cattle.	Blacksburg, Va. Steele's Tavern, Va.	T. J. Marlowe substituting for J. A. Gaines who is on leave.	Yes	2-C-1
AH d1-8 (rev.)	Evaluation of performance records in beef cattle.	Fayetteville, Ark.	Warren Gifford C. J. Brown	Yes	2-A-1,2
AH d1-9 (rev.)	The improvement of producing ability of beef cattle.	Knoxville, Tenn.	C. S. Hobbs R. S. Temple	Yes	2-A-2,7 2-B-1
AH d1-10 (rev.)	The improvement of beef cattle through breeding methods.	Ames, Iowa	L. N. Hazel	Yes	2-A-7 2-B-1
AH d1-12 (rev.#2)	Effectiveness of selection for productive efficiency and carcass quality and the importance of heterosis in beef cattle.	Ft. Robinson, Nebr. Lincoln, Nebr.	K. E. Gregory J. E. Ingalls	Yes	2-A-1,2 2-B-1,2 2-C-1 3-A-1
AH d1-13 (rev.#2)	The effectiveness of inbreeding and selection in the improvement of performance of beef cattle.	Brookings, S. Dak.	C. A. Dinkel	Yes	2-C-2
AH d1-14 (rev.)	Breeding and selection of beef for the Southwest.	Tucson and San Carlos, Ariz.	O. F. Pahnish	Yes	2-A-1
AH d1-16 (rev.)	A study of selection, inbreeding, and crossing of inbred lines within the Hereford breed.	Ft. Collins and Ft. Lewis, Colo.	H. H. Stonaker Kent Riddle	Yes	2-B-2 2-C-2
AH d1-17 (rev.)	Recurrent selection and record of performance selection in open and closed beef cattle herds.	Bozeman and Havre, Mont.	F. S. Willson	Yes	2-C-2
AH d1-18 (rev.)	Breeding beef cattle for Southwestern ranges.	State College, N.M.	L. A. Holland	No	
AH d1-19 (rev.)	The improvement of beef cattle through breeding methods using basic physiological differences in rate and efficiency of gains and carcass evaluation.	Corvallis, Ore.	Ralph Bogart	Yes	2-A-1
AH d1-20 (rev.)	The development of breeding techniques and selection criteria for improvement of economically important characteristics in Hereford and Shorthorn cattle.	Logan, Utah	J. A. Bennett	Yes	2-B-1,2
AH d1-22 (rev.)	The improvement of production and adaptation of beef cattle within purebreeds and certain of their crosses through breeding methods.	College Station and McGregor, Texas	T. C. Cartwright	Yes	2-A-1,4 2-B-2 2-C-1 3-A-1

Line Project Check List -- Reporting Year July 1, 1962, to June 30, 1963

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Project Incl. in Summary of Progress	Line Project Incl. in Area & Sub Subheading
AH dl-23 (rev.)	Genetic and environmental interactions for performance and carcass traits in beef cattle.	Raleigh, Plymouth, Laurel Springs and Butner, N. Carolina	E. U. Dillard	No	
AH dl-25 (rev.)	Improvement of beef cattle through the application of breeding methods: I. Criteria for improving effectiveness of selection. II. Head form studies, and III. Immunogenetics of beef cattle.	Laramie and Gillette, Wyo.	P. O. Stratton	Yes	2-B-1
AH dl-27 (rev.#2)	Relationships of beef and dairy characters in Milking Shorthorn cattle.	Rosemont and St. Paul, Minn.	C. L. Cole	No	
AH dl-28 (rev.)	A study to determine the breeding worth of inbred and outbred bulls from various sources.	State College and Prairie, Miss.	J. C. Taylor	No	
AH dl-29 (rev.)	Improvement of beef cattle of Alabama through breeding methods.	Auburn, Ala.	T. B. Patterson	Yes	2-A-1,4 2-C-1
AH dl-30 (rev.)	Improvement of reproductive performance in beef cattle.	Jeanerette, La. and Beltsville, Md.	W. L. Reynolds	Yes	2-A-4, 5 3-A-3, 5
AH dl-31 (rev.)	Effectiveness of selection for productive efficiency and carcass merit and the development of techniques for the identification of dwarfism carriers in beef cattle.	El Reno and Stillwater, Okla.	D. F. Stephens E. J. Turman	Yes	2-A-1
AH dl-32 (rev.)	Genetic-environmental influences on production and carcass traits in beef cattle.	Beltsville, Md.	E. J. Warwick	No	
AH dl-33	A study of reproductive physiology in range cattle.	Miles City, Mont.	R. A. Bellows	Yes	2-A-4 3-A-1,4
AH dl-34	Genetics of dwarfism in beef cattle.	Gainesville, Fla.	Marvin Koger	Yes	2-A-7
AH dl-35	A study of dwarfism in beef cattle*	Blacksburg, Va.	T. J. Marlowe	No	
AH dl-36	The effect of genetic-environmental interactions on selection responses in beef cattle.	Reno, Nev., and Branch Stations	C. M. Bailey	Yes	2-A-1
AH dl-37	Improvement of reproductive performance in beef cattle.	Ft. Robinson, Nebr.	J. N. Wiltbank		
AH dl-38 (C)	A study on genetic influences on growth, conformation and carcass characteristics of beef cattle.*	Brookings, S. Dak.	C. A. Dinkel	No	
AH dl-39	Biological and genetic analyses of normal and mutant stocks in beef cattle with special emphasis on dwarfism.	Davis, Calif.	P. W. Gregory	Yes	2-A-7
AH dl-40	Breeding experiments to investigate the nature of genetic improvement in beef cattle productivity with special emphasis on the performance of inbred lines and their crosses.	Davis, Calif.	W. C. Rollins	Yes	2-C-1
AH dl-41	A study of response to selection and genetic-environmental interaction in genetically similar groups of Hereford cattle at two locations.**	Miles City, Mont. Brooksville, Fla.	E. J. Warwick H. M. Kieffer W. C. Burns	Yes	2-A-5

* Terminated during reporting year.
** Initiated during reporting year.

Line Project Check List -- Reporting Year July 1, 1962, to June 30 1963

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Project Incl. in Summary of Progress	Line Project Incl. in Area & Sub Subheading
AH d2	Beef and Dual Purpose Nutrition Investigations.				
AH d2-3	Evaluation of feeds and forages for beef production in the Coastal Plains region.	Tifton, Ga.	B. L. Southwell	Yes	4-C-1
AH d2-8	Techniques for evaluation of feed intake, digestibility, and utilization of forage by grazing beef cattle and other livestock.	Beltsville, Md. Raleigh, N. C.	P. A. Putnam G. Matrone	Yes	4-A-1
AH d2-10	Cause and prevention of cattle losses on wheat and other pastures with special reference to grass tetany.	College Station, Texas	H. R. Crookshank	No	
AH d2-11	The effect of interrupted growth on the efficiency of beef production.	Beltsville, Md.	P. A. Putnam	No	
AH d2-12	Growth, development, and reproductive performance of heifers and cows under different winter treatments.	Fort Reno, Okla.	D. F. Stephens	Yes	4-D-1
AH d2-13	Cause and prevention of acute bloat in ruminants.	Beltsville, Md.	J. Gutierrez	Yes	4-A-2
AH d2-14	Nutritive value of feeds and forages as influenced by lignin, cellulose and other feed components.	Beltsville, Md.	P. A. Putnam	Yes	4-A-1
AH d2-21	Management and feeding practices affecting the gains of beef cattle on the range and in feedlot.	Ft. Robinson, Nebr.	J. E. Ingalls	Yes	4-D-1
AH d2-22	Determination of the relations between protein and energy deficiencies and reproductive ability of beef cattle.	Beltsville, Md.	J. Bond	Yes	3-A-1
AH d2-24	The effect of ruminal microorganisms on plant saponins and related compounds.	Beltsville, Md.	J. Gutierrez	Yes	4-A-5
AH d2-26	Studies on the nutritional relationships between the ruminal protozoa and bacteria and their contribution to digestion in cattle and other ruminants.	Beltsville, Md.	J. Gutierrez	Yes	4-A-5
AH d2-28	The relation of physical form and roughage content to the feeding value of beef cattle rations.	Beltsville, Md. Front Royal, Va. Fort Reno, Okla.	P. A. Putnam B. M. Priode D. F. Stephens	Yes	4-B-1
AH d2-30	Influence of harvesting factors on the nutritive value of corn and other grains.	Beltsville, Md.	C. A. Cabell	No	
AH d2-31	The cause and prevention of urinary calculi in fattening beef cattle and sheep.	College Station, Texas	H. R. Crookshank	Yes	4-A-3
AH d2-32	Investigations of residues of new pesticides when ingested by beef cattle.	Beltsville, Md. Tifton, Ga.	R. E. Davis B. L. Southwell	Yes	4-A-4
AH d2-34	Evaluation of pastures and forages in the Gulf Coast area in terms of reproductive performance by beef cattle.	Jeanerette, La.	W. L. Reynolds	Yes	3-A-1 4-B-2
AH d2-35	The interaction of nutrition and management in the growth and development of beef cattle.	Newell, N. Dak.	J. A. Minyard	No	

Line Project Check List -- Reporting Year July 1, 1962 to June 30, 1963

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in Summary of Progress	Line Proj. Incl. in Area & Sub-Subheading
AH d3	Beef and Dual Purpose Nutrition Investigations.				
AH d3-1	Sustained beef cattle production and maintenance of range quality in the Northern Great Plains by use of supplemental spring pastures.	Miles City, Montana	J. J. Urick	No	
AH d3-2	Management of pastures and cattle for beef production.	Brooksville, Florida	W. C. Burns	Yes	4-E-3
AH d3-3	Improving herd management on forest range.	Alapaha, Georgia	B. L. Southwell	No	
AH d3-4	Integration of livestock and timber production on intensively managed pastures.	Alapaha, Georgia	B. L. Southwell	No	
AH d3-6	The comparisons of the production of beef from beef, dual-purpose, and dairy steers.	Beltsville, Maryland	J. Bond, E. J. Warwick, R. E. Davis, J. W. Thomas, N. W. Hooven, R. L. Hiner	Yes	4-E-4 21-A-3
AH d3-7	Effects of management and growth variables on performance and carcass merit in beef cattle.	Fort Reno, Oklahoma	D. F. Stephens (1962)	No	
AH d4	Beef and Veal Studies.				
AH d4-4	Histological characteristics of muscle tissue of beef developed through breeding, nutrition and management.	Beltsville, Maryland	R. L. Hiner	Yes	21-A-1,3
AH d4-5 (C)	Characteristics of the eating quality of meat in relation to breeding and other production factors in beef.	College Station, Texas	Sylvia Cover	Yes	21-A-1
AH d4-6	Biochemical characteristics of beef tissue as affected by production of cattle.	Beltsville, Maryland	M. B. Matlack, R. L. Hiner	Yes	21-A-1
AH d4-7	Meat characteristics of carcasses of beef developed through breeding nutrition and management.	Beltsville, Maryland	R. L. Hiner	Yes	21-A-2,3
AH d4-8 (C) *	Production factors that influence beef tenderness and the development and evaluation of suitable methods for appraising tenderness.	Lincoln, Nebraska; Beltsville, Maryland	K. E. Gregory, C. H. Adams, R. M. Koch, W. J. Loeffel, V. H. Arthaud, R. L. Hiner, E. J. Warwick	Yes	21-A-1

*Discontinued during report year.

Line Project Check List -- Reporting Year July 1, 1962, to June 30, 1963

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Insts. in Summary of Progress	Line Proj. Insts. in Area & Sub-Subheading
AH e1	Poultry breeding investigations				
AH e1-42	Genetic and physiological studies of the red blood cell antigens in the domestic fowl.**	Beltsville, Md.		No	
AH e1-43	Evaluation of breeding systems for chickens.	Lafayette, Ind. & 11 North Central State Experiment Stations	S. P. Wilson & Cooperators	Yes	8-A-5 8-B-1,2
AH e1-44	Development and evaluation of breeding techniques in chickens.	Athens, Ga., & 14 Southern State Experiment Stations	R. E. Cook & Cooperators	Yes	8-A-4, 5, 6 8-B-2
AH e1-45	Genetic and physiologic bases for poultry improvement.	Twelve Northeastern State Exp. Stations	C. W. Hess & Cooperators	Yes	8-A-6
AH e1-46	Genetic and environmental factors affecting reproduction in turkeys.	Six Western State Experiment Stations	C. W. Hess & Cooperators	Yes	8-A-5
AH e1-47	Avian reproduction under sub-circadian periodicities.	Beltsville, Md.	H. L. Marks	Yes	8-A-3
AH e1-48	Genetic aspects of the ability of chickens to utilize amino acids.	Beltsville, Md.	C. W. Hess	Yes	8-A-1
AH e1-49	Genetic aspects of feed utilization in the chicken.*	Beltsville, Md.	C. W. Hess	Yes	8-A-2
AH e1-50	Breeding chickens for resistance to gonadotropic hormone inhibition.*	Athens, Ga.	R. E. Cook	No	
AH e2	Poultry nutrition investigations				
AH e2-13	Fat metabolism in poultry.	Beltsville, Md.	H. Menge & E. C. Miller	Yes	10-A-1, 10-B-1
AH e2-14	Feeding systems in poultry.	Beltsville, Md.	R. J. Lillie & P. F. Twining	No	
AH e2-15	Effect of high air temperatures on optimum levels of nutrient in diets for chickens.	Glendale, Ariz.	B. W. Heywang	Yes	10-A-1, 2 10-B-2 10-C-2
AH e2-16	Protein and amino acid requirements of chickens and turkeys.	Beltsville, Md.	P. F. Twining & R. J. Lillie	Yes	10-A-2 10-C-3, 4
AH e2-17	Cottonseed meal in chicken diets.	Glendale, Ariz.	B. W. Heywang	Yes	10-C-1
AH e2-18	Mineral requirements of poultry.	Beltsville, Md.	C. A. Denton R. J. Lillie & P. F. Twining	Yes	10-A-3
AH e3	Poultry physiology investigations				
AH e3-15	Neural-pituitary functions in egg producing fowl.**	Beltsville, Md.	H. Opel & R. M. Fraps	Yes	9-A-1
AH e3-16	Effect of controlled photoperiods on growth and egg production.	Glendale, Ariz.	R. W. Lowe & B. W. Heywang	No	
AH e3-17	Egg production efficiency of caged and floor-housed pullets.	Glendale, Ariz.	R. W. Lowe & B. W. Heywang	No	
AH e3-18	Effect of environment and reproduction in turkeys.	Beltsville, Md.	S. J. Marsden & R. M. Fraps	Yes	9-B-1
AH e3-19	Parthenogenesis in avian eggs.	Beltsville, Md.	M. W. Olsen & H. K. Poole R. M. Fraps	Yes	9-A-2
AH e3-20	The homograft reaction and immunological tolerance in birds.	Beltsville, Md.	H. K. Poole & M. W. Olsen, R. M. Fraps	Yes	9-A-3

* Initiated during reporting year.
** Discontinued during reporting year.

Line Project Check List -- Reporting Year July 1, 1962, to June 30, 1963

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in Summary of Progress	Line Proj. Incl. in Area & Sub-Subheading
AH e4	Poultry meat and egg quality as affected by nutrition, breeding physiology and other management factors.				
AH e4-9	Effect of age, sex, breed and management on the physical, chemical and morphological characteristics of poultry skin.	Beltsville, Md.	E. H. McNally	No	
AH e4-10	Effect of breeding and management of the flock on the chemical and morphological characteristics of the yolk and yolk membrane of chicken eggs.	Beltsville, Md.	E. H. McNally	Yes	21-D
AH e5	National Poultry Improvement Plan (There are no line projects under this work project).	Beltsville, Md. In cooperation with 47 Official State Agencies (Alaska, Hawaii and Nevada not included)			
AH e6	Improvement of viability of poultry.				
AH e6-2 (Rev.#2)	The development and maintenance of inbred lines of chickens showing a wide range of resistance and susceptibility to avian lymphomatosis.	East Lansing, Michigan	L. B. Crittenden and T. N. Fredrickson	Yes	11-B
AH e6-3	A research program for the production and the maintenance of susceptible chickens free of lymphomatosis.	East Lansing, Michigan	L. B. Crittenden	Yes	11-B
AH e6-10 (Rev.#2)	A study of the characteristics of the causative agent of visceral lymphomatosis in the chicken.	East Lansing, Michigan	B. R. Burmester	Yes	11-A-1
AH e6-17	Studies on the immunity of chickens to visceral lymphomatosis.	East Lansing, Michigan	B. R. Burmester	Yes	11-C
AH e6-20	Identification of cell types found in the lesions and blood of chickens with the different forms of the avian leukosis complex.	East Lansing, Michigan & AMS, Wash.	A. M. Lucas & E. M. Denington	No	
AH e6-21(C)	Effect of feeding cod liver oil on the occurrence of lymphomatosis in chickens.	East Lansing, Michigan & Univ. of Wisc. Madison, Wisc.	B. R. Burmester & B. Winton	No	
AH e6-24	Propagation and characterization of the visceral lymphomatosis virus in tissue culture.	East Lansing, Michigan	B. R. Burmester	Yes	11-A-2
AH e6-25	The effect of environment conditions on the incidence of visceral lymphomatosis among young chickens.**	Reg. Poult. Lab. & Mich. State Univ., East Lansing, Mich.	B. R. Burmester	No	
AH e6-26	Studies on the anatomy of the domestic fowl including the skeletal, muscular, circulatory and nervous system.	East Lansing, Michigan	A. M. Lucas	Yes	1-B-1
AH e6-27	Studies on the epizootiology of avian lymphomatosis and related neoplasms.	Penn., Va., N. J., and Mich.	B. R. Burmester	Yes	11-D
AH e6-28	A study of the genetic variability remaining in highly inbred lines of chickens.	East Lansing, Michigan	L. B. Crittenden & W. Okazaki	Yes	11-B

** Discontinued during reporting year.

Line Project Check List -- Reporting Year July 1, 1962, to June 30, 1963

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in Summary of Progress	Line Proj. Incl. in Area & Sub-Subheading
AH e7	Relation of environment and management to disease and broiler condemnations.	State College, Mississippi			
AH e7-1	Factors influencing airsacculitis and condemnations in broilers.	State College, Mississippi	R. T. Parkhurst	Yes	12-B

Line Project Check List -- Reporting Year July 1, 1962, to June 30, 1963

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl.in Summary of Progress	Line Proj. Incl.in Area & Sub-Subheading
AH f1	Fur animal breeding (including rabbits)				
AH f1-1	Genetic investigations of traits for use in breeding and selection for improvement of meat rabbits.	Fontana and Davis, Calif.	R. B. Casady	Yes	18-A-1, B-3
AH f1-2	Genetics of mink and marten with emphasis on mutant characters and pelt quality.	Madison, Wisc.	R. M. Shackelford	Yes	18-A-2
AH f1-3	Development of a superior strain of blue foxes.	Petersburg,Alaska	J. R. Leekley	No	
AH f1-4	Marten mating systems to increase breeding regularity and prolificacy.	Petersburg,Alaska	J. R. Leekley	Yes	18-B-2
AH f1-6	Effect of breeding does at various intervals following kindling on the growth and weaning weight of the young and on reproductive performance of the doe.	Fontana, Calif., Beltsville, Md.	R. B. Casady	Yes	18-B-4
AH f1-7	Investigations of spontaneous glaucoma.	Fontana and Los Angeles, Calif.	R. B. Casady	No	
AH f2	Fur animal physiology of reproduction				
AH f2-1	Effect of hormones on growth and reproduction of mink.	Swarthmore, Pa.	R. K. Enders	Yes	18-B-1
AH f2-3	Management factors affecting reproductive performance in mink.	Ithaca, New York	H. F. Travis	No	
AH f2-4	A study of lactation in the mink.	Swarthmore, Pa.	R. K. Enders	No	
AH f3	Fur animal feeding and nutrition				
AH f3-1	Development of diets based on sea fish and sea mammals and their products for blue fox, mink and marten.	Petersburg, Alaska	J. R. Leekley, C. A. Cabell	Yes	18-C-1
AH f3-2	Relationship of nutrient factors and physical characteristics in diet to rabbit production.	Fontana, Calif.	R. B. Casady	Yes	18-C-2
AH f3-4	Study of various proteins as rabbit feed.	Fontana, Calif., Beltsville, Md.	R. B. Casady	Yes	18-C-3
AH f3-5	Investigations of the basic nutrient requirements and nutrient utilization by mink.	Ithaca, New York	H. F. Travis	Yes	18-C-4
AH f3-6	The development of practical diets and feeding practices for mink.	Ithaca, New York	H. F. Travis	Yes	18-C-5
AH f3-7	Investigation of hydrocephalus in vitamin A deficient rabbits.	Fontana and Los Angeles,Calif.	R. B. Casady	No	
AH f4	Fur fiber and fur investigations				
AH f4-3	The priming process in fur bearing animals.	Beltsville, Md.	E. H. Dolnick	Yes	18-B-5, C-6
AH f4-4	Influence of endocrine factors on the development of hair follicles within the skin of fur-bearing animals.	Beltsville, Md.	E. H. Dolnick	No	

Line Project Check List -- Reporting Year July 1, 1962, to June 30, 1963

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in Summary of Progress	Line Proj. Incl. in Area & Sub-Subheading
AH g1	Genetics and interrelations of anatomical and physiological characteristics of dairy cattle.				
AH g1-1	Genetic and phenotypic relation of body form in the growing heifer to body form and producing capacity in the cow.	Beltsville, Md. Urbana, Ill. Columbus, Ohio Lafayette, Ind. St. Paul, Minn.	R. D. Plowman C. A. Matthews	Yes	5-A-3
AH g1-2	Genetic and phenotypic interrelationships between body form, internal anatomy and milk production in the cow.	Beltsville, Md.	R. D. Plowman C. A. Matthews	Yes	5-A-2
AH g1-3	Studies of the rate and form of mammary gland development in cattle at different ages, in relation to milk production.	Beltsville, Md. St. Paul, Minn. Huntley, Mont. Columbus, Ohio Lewisburg, Tenn. Madison, Wisc.	R. D. Plowman C. A. Matthews	Yes	5-A-4
AH g1-4	Studies of the genetics of feed utilization in dairy cattle.	Beltsville, Md. Ithaca, N. Y. Lewisburg, Tenn. Jackson, Tenn. Huntley, Mont. Bozeman, Mont. Logan, Utah	N. W. Hooven, Jr. G.W. Trimberger J. Owen B. Hazelwood D. Kopland J. Boyd R. Lomb	Yes	5-A-1
AH g1-5	Studies of the genetics of milk constituents and other properties related to milk production.	Beltsville, Md. East Lansing, Mich. Madison, Wisc.	C. A. Kiddy	Yes	5-A-8
AH g1-6	A study involving the repeatability and standardization of blood typing in dairy cattle.	Beltsville, Md. and cooperating laboratories	C. A. Kiddy R. D. Plowman	Yes	5-A-7
AH g1-7	The importance of immunogenetic factors in problems of lowered fertility in cattle.	Beltsville, Md.	C. A. Kiddy H. W. Hawk	No	
AH g1-8	Antibodies in bovine milk.	Beltsville, Md.	C. A. Kiddy R. D. Plowman W. D. Schultze	Yes	7-D-3
AH g1-28	Relationships of beef and dairy characteristics in milking Shorthorn cattle.*	St. Paul, Minn. Waseca, Minn.	C. L. Cole W. F. Aunan R. D. Plowman E. J. Warwick	No	
AH g2	The application of advanced genetic concepts and principles for the improvement of dairy cattle.				
AH g2-5	Developing and evaluating desirable production characteristics in Holstein cattle by inbreeding, out-breeding and inter-line crossing.	Lake Mills, Wisc. Madison, Wisc.	W. J. Tyler	Yes	5-B-1
AH g2-22	Studies to estimate the relative importance of general and specific combining ability in relation to breeding dairy cattle	St. Paul, Minn. Columbus, Ohio	C. W. Young T. M. Ludwick	Yes	5-B-2

Line Project Check List -- Reporting Year July 1, 1962, to June 30, 1963

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Summary of Progress	Incl. in Area & Sub-Subheading
AH g2-23	Usefulness of heterosis from interbreed matings.	Illinois	R. W. Touchberry	Yes	5-B-5
		Indiana	T. G. Martin	Yes	
		Beltsville, Md.	R. E. McDowell	Yes	
AH g2-24	The influences of parental relationship on the genetic merit of dairy sires and cows.	Beltsville, Md.	R. D. Plowman	Yes	5-B-3
AH g2-25	The value of the continuous use of progeny tested sires and sons of progeny tested sires for improving dairy cattle.	Beltsville, Md.	R. D. Plowman	Yes	5-B-4
AH g2-26	Comparisons of genetic methods of using sires available in artificial breeding of dairy cattle.	St. Paul. Minn.	C. W. Young	No	
AH g2-27	A comparison of selection for milk production with selection for total fat production in dairy cattle.	Cortland, N. Y.	G. W. Trimberger C. R. Henderson	No	
AH g3	Investigations of dairy herd management.				
AH g3-8	Evaluation of management practices for the control of bovine mastitis.	Beltsville, Md.	W. D. Schultze	Yes	7-D-1
AH g3-10	Electrically controlled and operated equipment for reduction of labor in dairy production.	Beltsville, Md.	R. D. Plowman	No	
AH g3-12	Evaluation and development of equipment and physical methods for control of flies and other dairy cattle pests.	Beltsville, Md.	R. D. Plowman	Yes	7-D-4
AH g4	Factors influencing dairy cattle adaptability.				
AH g4-1	Relationship of anatomical and physiological characteristics to dairy cattle adaptability.	Louisiana	J. E. Johnston	Yes	6-D-1-2
		Georgia	J. C. Johnson	No	
		Beltsville, Md.	R. E. McDowell	Yes	
AH g4-2	Genetic methods for developing adaptability.	Texas	M. A. Brown	Yes	7-D-5(a-f)
		Louisiana			
		LSU	C. Branton	Yes	
		Iberia	B. Hollon	Yes	
		Georgia			
		Reidsville	J. C. Johnson	Yes	
		Tifton	J. C. Johnson	Yes	
AH g4-3	Influence of management practices and other environmental factors on adaptability of dairy cattle to hot and humid regions.	Beltsville, Md.	R. E. McDowell	No	7-D-6
		Georgia	J. C. Johnson	Yes	
		Louisiana			
		LSU	C. Branton	Yes	
		Iberia	B. Hollon	Yes	
AH g5	Evaluation of concepts for procurement, interpretation and use of dairy herd records				
AH g5-1	Studies on methods for minimizing environmental influences on production records of individual cows and progeny records.	Madison, Wisc. Beltsville, Md. College Park, Md.	E. L. Corley	Yes	7-D-2

*Initiated during reporting year.

Line Project Check List -- Reporting Year July 1, 1962, to June 30, 1963

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl.in Summary of Progress	Line Proj. Incl.in Area & Sub-Subheading
AH h1	The nutritional factors affecting normal growth and health of calves and growing cattle.				
AH h1-1	Factors affecting the intake of hay-crop silage by dairy heifers.	Beltsville, Md.	L. A. Moore D. R. Waldo	Yes	7-C-1
AH h2	A study of nutritional and related factors affecting the usefulness of producing dairy cattle				
AH h2-3	Studies on the microbiology of the bovine rumen.	Beltsville, Md.	M. P. Bryant D. R. Caldwell K. A. Pittman	Yes	1-D
AH h2-5	Factors involved in the efficiency of forage utilization by dairy heifers.	Bozeman, Montana	L. A. Moore D. R. Waldo R. D. Plowman D. V. Kopland	No	
AH h2-6	Development and use of chemical methods for determining the nutritive values of dairy feeds and forages.	Beltsville, Md.	L. A. Moore P. J. Van Soest	Yes	7-A-(8a bcd)
AH h2-7	The measurement of heat production by grazing cattle.	Beltsville, Md.	L. A. Moore D. R. Waldo	Yes	7-A-9
AH h2-8	Determination of the nutritive value of cattle feeds by calorimetric methods.	Beltsville, Md.	L. A. Moore W. P. Flatt	Yes	7-A-(1-7) 7-A-(10)
AH h2-9	Extent to which agricultural chemicals are secreted into milk.	Beltsville, Md. Tifton, Georgia	L. A. Moore J. C. Derbyshire	Yes	7-A-10
AH h2-10 (C)	Study of the metabolism and excretion of ingested radionuclides in relation to nutrition and health of farm animals and to the accumulation of radionuclides in animal food products.	Beltsville, Md. Ithaca, N.Y.	G. F. Fries	Yes	1-H-1 & 2
AH h2-11	A study of the efficiency of use of metabolizable energy.	Beltsville, Md.	L. A. Moore E. A. Kane	No	
AH h3	Studies on management, preservation and utilization of grassland crops for dairy cattle.				
AH h3-1	A biochemical study of the ensiling of forage crops.	Beltsville, Md.	L. A. Moore H. G. Wiseman C. H. Gordon	Yes	7-B-1d
AH h3-3	A study of the effects of kinds of crops, kinds of treatment, methods of handling and condition of storage of forage on the resulting silages and the production of silages suitable for fundamental bacteriological and biochemical studies.	Beltsville, Md.	L. A. Moore C. H. Gordon	Yes	7-B-1a-b 7-B-3
AH h3-12	Investigations of factors affecting forage production of Tennessee grasslands for dairy cattle.	Lewisburg, Tenn.	L. A. Moore D. R. Waldo	Yes	7-B-1c
AH h3-17	The relation of date of cutting and dry matter content when cut to digestibility, consumption and acre yields of forage crops.	Huntley, Montana Logan, Utah	L. A. Moore D. R. Waldo M. J. Anderson	No	
AH h3-18	The effect of varying stacking rates on nutrient yields per acre of orchardgrass-ladino clover pastures on production per animal of dairy cows grazing these pastures.	Beltsville, Md.	L. A. Moore C. H. Gordon J. C. Derbyshire	Yes	7-B-2a
AH h3-9	A study of practical ensiling procedures and evaluation of resulting silages with dairy cattle.**	Lewisburg, Tenn.	L. A. Moore D. R. Waldo	Yes	7-B-1c

**Discontinued during reporting year.

Line Project Check List -- Reporting Year July 1, 1962, to June 30, 1963

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in Summary of Progress	Line Proj. Incl. in Area & Sub-Subheading
AH h4	Bioassay of nutritional requirements and processes of dairy cattle.				
AH h4-1	Unidentified nutrients in feeds and milk.	Beltsville, Md.	L. A. Moore A. M. Hartman L. P. Dryden	Yes	1-C-3
AH h4-3	Relation of Vitamin B_{12} to ruminant metabolism.	Beltsville, Md.	L. A. Moore A. M. Hartman L. P. Dryden	Yes	1-C-1 1-C-2
AH h5	Physiological studies of reproduction, mammary gland growth and lactation in dairy cattle.				
AH h5-1	Hormonal and nutritional aspects of mammary growth and lactation.	Beltsville, Md.	J. Bitman T. R. Wrenn	Yes	6-B-1 1-B-4
AH h5-2	Development of methods for the determination of secretion rate and metabolism of hormones in dairy cattle.	Beltsville, Md.	J. Bitman H. C. Cecil	No	
AH h5-3	Physiological mechanisms related to reproductive performance of dairy cattle.	Ithaca, N. Y.	J. Bitman H. W. Hawk W. Hansel	Yes	6-A-3 6-A-4 6-C
AH h5-4	Pre and post-ovulatory factors affecting fertilization and embryonic survival in dairy cattle.	Amherst, Mass.	H. W. Hawk W. L. Black	Yes	6-A-4 6-A-5
AH h5-6	Physiological basis for variations in fertilization success and embryo survival that may be associated with lowered fertility in dairy cattle.	Madison, Wisc.	J. Bitman H. W. Hawk L. E. Casida	Yes	6-A-1 6-A-2
AH h5-8	Endocrine influences on embryonic mortality and uterine physiology.	Beltsville, Md.	H. W. Hawk J. Bitman	Yes	 1-B-2

Line Project Check List -- Reporting Year July 1, 1962, to June 30, 1963

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl.in Summary of Progress	Line Proj. Incl.in Area & Sub-Subheading
AH i4	Dairy herd improvement research through analysis of data collected in national cooperative dairy herd improvement and sire-proving programs and the development of effective production testing organizations.				
AH i4-1	Research on the evaluation of superior sires and cows in the national dairy herd and on the factors affecting these estimations.	Beltsville, Md.	R. H. Miller E. L. Corley	Yes	20-A-1
AH i4-2	Analysis of different types of records of performance and breeding society organizations, testing plans, methods and forms used in collecting and evaluating production records to improve the effectiveness of DHIA sire-proving and related programs.	Beltsville, Md.	R. H. Miller E. L. Corley	Yes	20-A-2
AH i4-3	Analysis of DHIA cow and herd production records to determine from year to year the relationships between yield, feed inputs, costs, and related factors.	Beltsville, Md.	R. H. Miller E. L. Corley	Yes	20-A-3

Line Project Check List -- Reporting Year July 1, 1962 to June 30, 1963

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in Summary of Progress	Line Proj. Incl. in Area & Sub-Subheading
AH j1	Humane Slaughter of Meat Animals				
AH j1-1 (C)*	Methods suited to small packing plants for using carbon dioxide and other gases to induce anesthesia in swine, sheep and calves prior to slaughter.	Ithaca, N. Y., Beltsville, Md.	R.W. Douherty, N. R. Ellis	Yes	21-F-1
AH j1-2*	Humane slaughtering techniques as they influence procedures and quality of meat.	Beltsville, Md.	R. L. Hiner	Yes	21-F-2
AH j1-3	Electrical stunning as a method of inducing anesthesia in humane slaughtering of meat producing animals	St. Paul, Minn., Beltsville, Md.	R.L. Kitchell, R.L. Hiner	Yes	21-F-3

* Discontinued.

Line Project Check List -- Reporting Year July 1, 1962, to June 30, 1963

Work & Line Project Number	Work and Line Project Title	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in Summary of Progress	Line Proj. Incl. in Area & Sub-Subheading
	Pioneering laboratories				
AH P-1	Pioneering Blood Antigen Laboratory	Beltsville, Md.	S. L. Scheinberg	Yes	1-A-2
AH P-2	Pioneering Research Laboratory in Basic Animal Genetics	Lafayette, Ind.	Wendell H. Kyle	Yes	1-A-1
	Projects delegated to AH by AMS	Beltsville, Md.	Karl Hoke	Yes	21-[illegible]-1,2
MQ 3-34	Basic research on quality evaluation and development of objective measurement of quality factors in agricultural products		R. L. Hiner		
	PL 480 projects				
A7 AH-1	Physiology and genetics of characteristics influencing the adaptability of cattle and buffalo for dairy production in India; genetic methods for developing adaptability and the effect of climatic elements and other environmental influences on adaptability.	India	S. Guha	Yes	6-D-3
A7 AH-6	Nutritional physiology of different breeds of Indian cattle	Karnal, India	S. W. Ray	No	
A7 AH-11	Factors affecting the utilization of low-grade roughages and production of volatile fatty acids in the rumen of cattle.	India	G. S. Sidhu	No	
A10 AH-3	The mechanism of lactation and its augmentation by hypothalamic stimulation	Jerusalem, Israel	F. G. Sulman	Yes	6-B-2
A10 AH-7	Utilization and function of vitamin A in nutrition of poultry.	Israel	A. Bondi	No	
A10 AH-12*	The separation of young and old spermatozoa	Rehovot, Israel	R. Volcani	No	
A10 AH-13*	Factors acting in long-term storage of sperm in vivo.	Rehovot, Israel	R. Volcani A. Schindler	No	
A22 AH-2*	White muscle disease of lambs in Turkey	Ankara, Turkey	Cahit Ozcan	No	
E8 AH-1	Breed differences regarding the antigenic properties of cattle blood, their inheritance in relation to economic characteristics and genetic origin of the breed	Tikkurila, Finland	Viljo Vainikainen	Yes	5-A-7
E21 AH-1	Secretion of anterior pituitary hormones and ovulation in small ruminants.	Jabtonna near Warsaw, Poland	F. Domanski	Yes	1-B-4
E21 AH-2	Color in pork as influenced by heredity, sex, age, feeding and management of animals	Warsaw, Poland	M. A. Janicki	Yes	21-C-3
E21 AH-4	Investigations of blood groups in a new racial group of the "Zlotnicka Pig"	Poznan, Poland	Antonio Kaczmarek	No	
E21 AH-5	Protein compounds of vitamin B_{12} and its analogs	Poland	J. Janicki	No	
E21 AH-6	Trace element contents in forage crops in relation to the stage of development of the plants, method of gathering and storage	Poland	K. Gawecki	No	

Line Project Check List -- Reporting Year July 1, 1962, to June 30, 1963

Work & Line Project Number	Work and Line Project Title	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in Summary of Progress	Line Proj. Incl. in Area & Sub-Subheading
E25 AH-4	Contribution to the study of metabolism of zinc in living organisms by means of zinc 65	Madrid, Spain	Carmen Garcia Amo	Yes	1-E
F4 AH-1*	Improving and evaluating Fayoumi and Dandarawi fowls	Dekki, Giza, UAR, Egyptian Region	I. F. Sayed	No	
S3 AH-7	Structural and physiological characteristics associated with adaptability of cattle in tropical and subtropical areas	Brazil	J. S. Ziega	Yes	6-D-4
S5 AH-1	Evaluation of the native breed, Costeno con Cuernos, and European breeds and European native breed crosses when managed and selected for dairy cattle traits under the hot and humid conditions of Northern Columbia	Columbia	R. K. Waugh	Yes	5-B-6
S9 AH-1	The nutritional value of the fish silage produced by yeasts fermentation for animal feeding	Uruguay	Victor H. Bertullo	Yes	1-F

* Initiated during reporting year.